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Modeling the Economic Development of A Poorly Endowed Region: The Northeast of Thailand

John Enos

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PREFACE

This Memorandum presents, for the first time to the author's knowledge, an application of a relatively new method of analysis -- the simulation model -- to a particular underdeveloped economy. Previous applications have been to hypothetical economies, making it impossible (rather than merely difficult) to test the behavior of the models against reality. Useful econometric models of developed countries, for whose economies statistics are readily available, have appeared in the literature, and it is felt that simulation as a technique would be equally useful in the analysis of underdeveloped countries, for whose economies few data are available.

Empirically, the study collects in one work most of the available information of interest on the economy of the Northeast of Thailand. It suggests what additional information is most needed to increase the knowledge of the economy, and it identifies what seems to be a problem that will confront the region in the near future -- growing unemployment. It is hoped that, as various economic data become available in the 1970s, this and other findings of the study can be tested against actual occurrences.

Review of this work in draft form brought forth dissenting views on the validity of applying a three-sector model to an economically variegated region like Northeast Thailand, and some objection to the complexity of the model (over one hundred equations). The author leaves these views to the test of the reader's responses. In recognition of the usefulness of Occam's Razor, however, he has supplied a simplified analytic model in Appendix C.

This work was sponsored in major part by the Advanced Research Projects Agency of the Office of the Secretary of Defense. The study has benefited from the comments of T. K. Glennan, Jr., F. P. Hoeber, A. W. Marshall, R. R. Nelson, G. Shubert, V. Taylor, and C. Wolf, Jr., and from the editorship of M. Palmatier, H. Porch, and D. Sapriel.

SUMMARY

In this Memorandum a new technique is used to study the economic prospects of a recently troubled area. The technique is "simulation" -- the formulation of a complex mathematical model of a system in the real world and the computation, electronically, of its behavior over an arbitrary period of time. The area chosen for the study is the 15 provinces of Northeastern Thailand, occupying one-third of the country's land and inhabited by one-third of its population. Contiguous with Laos and Cambodia, and as close to Vietnam as it is to the central plain of Thailand, the Northeast has become, within the last few years, a matter of world concern. The present Memorandum is an expression of this concern, and focuses on the opportunities for employment of the generation now growing up within the region.

The model of the economy of the Northeast consists of three sectors: agriculture, now supporting approximately 90 percent of the population; industry and commerce; and government. The last two are small but growing rapidly. Employment is provided, and investment and production carried out, by all sectors; the incomes earned are allocated among saving and the consumption of agricultural and industrial goods on the basis of individual preferences and relative prices. The policy instruments of government included in the model are the level and incidence of taxes; the number and salaries of civil servants; the rate of establishment of new industrial and commercial firms; the level of public investment and its division among agriculture, industry, and family planning; and the internal price of the main item of food -- rice. These relationships are expressed mathematically in a little over one hundred equations.

The model of the economy of the Northeast is simulated, under various economic conditions and with various government policies, on a computer, commencing with the year 1960 and terminating with 1985. The quantitative "histories" that are traced out, one for each set of conditions and policies, are then compared in an effort to determine the likely effects of the alternatives.

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The outcomes for all cases are depressing. The rates of growth of the population and of entrants into the labor force are more rapid than the rates of growth of employment, at least for the decade 1970-1980, and of the production of food, throughout. To be sure, employment, output, and income all rise steadily, and the majority of the population betters its standard of living, but an increasing minority is unable to participate in the general advance.

These are the results of simulating the model and are of interest only to the extent that the structure and initial conditions of the model accurately portray the economy of the Northeast, and that the values of the exogenous variables throughout the simulation accurately reflect real forces. Our ability to test the model for these qualities is quite limited. We can and have examined the individual equations in the light of economic theory and empirical fact, and we can and have observed its overall behavior, but we have not been able to compare over a period of time the behavior of the model with reality. The data have just not been available. Such sources of statistics as we were able to draw upon -- mainly the Population and Agricultural Censuses, Household Budget Studies, and Regional Income Breakdown carried out at the beginning of the 1960s -- did enable us to determine the actual values of all the variables in the model at one instant in time but at no subsequent or previous instants. We have no real history with which to compare our simulated "histories." Unless special surveys are made, any comparison will have to await the next body of statistics available in the mid-1970s.

It would hardly be worthwhile gathering contemporary data if the sole purpose were to test the behavior of a theoretical model against experience. But it might be worthwhile trying to discover the pervasiveness of unemployment in the region and the existing values and trends in certain other variables (for example, the mobility of labor and the possibility of its more intensive use in agriculture) on which the simulations of the model have indicated unemployment to be most dependent. The implication of the study -- that unemployment in the Northeast is going to increase substantially in the 1970s, and perhaps beyond -- seems grave enough to warrant further research.

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I. INTRODUCTION TO THE STUDY

In faith and governance the world will disagree, but all mankind's concern is subsistence. That an outsider should attempt to prescribe more rapid economic development for Thailand's poorest region may be excused then, given his belief that without development an increasing number of its inhabitants will lack food, clothing, and shelter.

The Northeast of Thailand can generate the problem, but it cannot produce the answer. One result of this study of the prospects for the Northeast will be to demonstrate the need for a national effort. To maintain the material progress that the Thai of the Northeast have made in recent years and to meet the expectations which they are beginning to hold for the future will require a steady and substantial growth in output and income, something probably beyond the ability of the region alone to provide. The talents of the whole nation must be drawn upon.

Development is change for the better. If it is to provide useful employment for all inhabitants, the Northeast must not only remarkably increase its total output of goods and services but also drastically transform their composition. Agriculture, which occupies most of the population now, will not be able to satisfy all its future needs, for desirable goods, productive expansion, and challenging jobs come most of all with industrialization. Without industrialization, there arise simultaneously the heightening of the aspirations of all and the achievement of only a few; in employment applicants outstrip openings and expectations earnings.

To transform its agricultural society the Northeast will have to seek assistance from the more advanced regions. But the Northeast has always looked outside for direction and design. Its geography has been conducive to poverty and isolation; its history, to dependence and disaster. No sects have originated there, no heroes have emerged, no cultures or empires have been created. The Northeast has never been more than a link, a channel, or a connection.

GEOGRAPHY OF THE REGION

The subordinate role of the Northeast is symbolized in the map of Thailand. It seems appropriate that this country, which venerates the white elephant, should territorially so resemble one. In an atlas of southeast Asia it appears in profile, facing west (see Fig. 1). The mouth is at Bangkok; the trunk extends south along the Malay peninsula. The ears are the northern provinces, erect as if tuned in to vibrations from China. The neck is the Northeast of Thailand, and it is on this tracheal region that we shall focus.

In its geography the Northeast of Thailand is a single unit. It occupies about 63,000 square miles, one-third of the territory of Thailand. Geologically, it consists of the Khorat plateau of horizontal layers of sandstone and shale tilting gradually toward the Mekong River to the east, from an elevation of about 200 meters at the western end to one of approximately 100 meters at the river. The western and southern edges of the plateau are rimmed by ridges of hills rising several hundred meters, making communication with the rest of Thailand difficult. To the north and east the Mekong River forms the boundary between Thailand and Laos; in this stretch the river varies in width between 200 and 500 meters. Occasional rapids prevent transportation over long distances up and down the river, but travel across is relatively easy.

The Northeast is part of the Mekong watershed. In the northern third of the region several short tributaries flow out of low-lying hills to join the Mekong, but the southern two-thirds of the Khorat plateau is part of a single drainage basin formed by two large rivers, the Chi and the Mun. The former flows in a southeasterly direction and the latter in an easterly direction, the two uniting near the city of Ubon. Their combined waters empty into the Mekong at the point where it bends eastward into Laos. These rivers provide not only local transportation but also water for irrigation, supplementing the rain, which is unreliable and often inadequate. The southwest monsoon, blowing between May and October, yields ample rainfall for the central valley of Thailand, but it loses much of its moisture there and on the

Fig. 1 — Map of Southeast Asia

western slopes of the escarpment, so that the rains descending upon the Khorat plateau are considerably diminished. In addition, the top-soil holds very little moisture and the underlying strata are flat and impermeable, letting the water run off quickly. Consequently, the higher lying lands are arid while the lower lying are flooded -- at least during and shortly after the southwest monsoon.

Not only the land but also the character of the people of the Northeast tilts towards Laos. Ethnically the populations of the Northeast of Thailand and of Laos are the same, being known as Lao-Thais and Laos, respectively in the two countries. They are inlanders, remote from the intercourse and commerce of the rest of the world. They are growers of rice, a particular glutinous variety which each man cultivates on his own land, and herders of buffalo and cattle, which they sell abroad.

HISTORY OF THE REGION

To the Thais of the Central Plains the speech of the Lao-Thais is quite intelligible, although considered a dialect; their culture familiar, although considered primitive; their poverty unfortunate, although inevitable. The Thais of the Central Plains have been to the Lao-Thais not equals but superiors, not compatriots but overlords.

This inequality was not always so; the Thai tribes that originated in the Chinese province of Yunnan, south and west of the Yangtze River, had joined forces as early as the seventh century A.D. In alliance they conquered the northwest portion of Yunnan, calling themselves the kingdom of Nanchao. After two centuries of independence, they were conquered by the Chinese. Subsequently as vassals in Yunnan and as tributaries in Thailand, the Thais have honored and feared the Chinese.

While achieving dominion in Yunnan, the Thai tribes also began to expand to the south, moving along the major rivers -- the Irrawaddy, the Salween, and the Mekong -- which for many miles flow parallel through the gorges of eastern Tibet, southwestern Szechwan, and

northwestern Yunnan. The Thai followed these valleys until they had penetrated the delta of the Irrawaddy, the middle reaches of the Mekong and Salween, and over the hills to the Chao Phraya, which drains the central plain of Thailand.

It was in the valley of the Chao Phraya that the strongest of the Thai kingdoms, the Siamese, came to be established. To the west, the Burmese had resisted the southern movement of the Thais, as had the Annamese to the east. One of the peoples of Vietnam, the Annamese (themselves probably descendants of tribes formerly inhabiting the coastal region of southern China) so successfully combatted the Thai that those who entered northern Tonkin were never able to descend into the central plain, remaining to this day in the rugged, mountainous interior.

The Thai who advanced along the Mekong and those who filtered through the mountains down along the tributaries of the Chao Phraya found the territory thinly populated and ineffectually occupied by the Khmer. The Khmer's Hindu civilization, which had (as in Indonesia) reached its peak in the twelfth century with the building of the capital and its adjacent temples, Angkor and Angkor Wat, offered less resistance to the Siamese. By the middle of the thirteenth century, the Siamese had gained control of Chao Phraya plain; by the end of the next century they had raided the Khmer capital, kidnapped a large part of the population and achieved sovereignty over the remainder. About the same time another branch of the Thai, the Shan, created a kingdom in northern and eastern Burma, and a third branch, the Lao, combined their holdings -- covering approximately the area occupied by Laos today -- into the empire of Lan Xang.

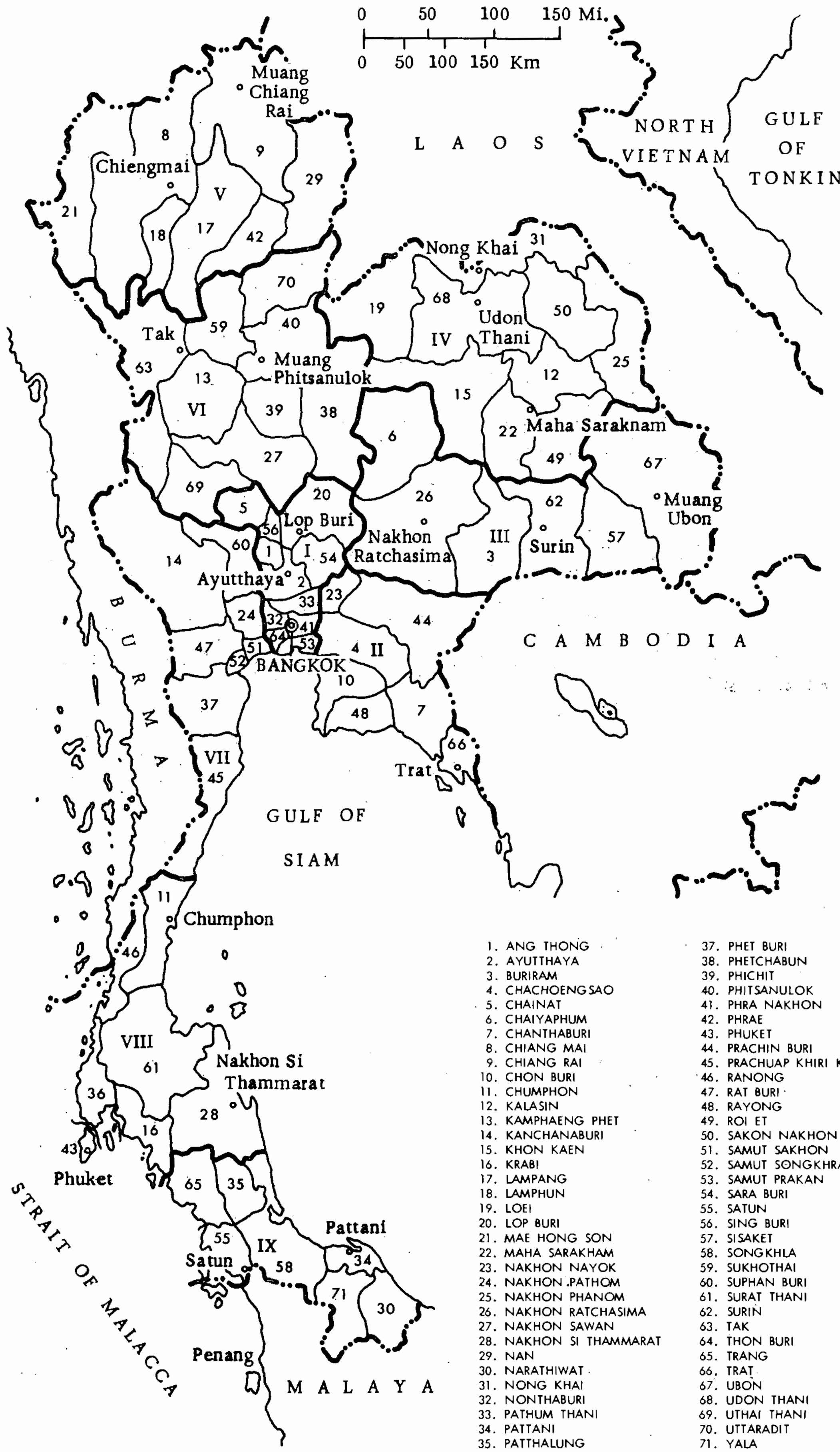
During the migrations and wars, the Northeast of Thailand remained largely uncontested. To a people accustomed to living in the river valleys, where they cultivated rice under irrigation, the Northeast with its infertile soil and arid climate held little appeal. Nor was it (at least not for several centuries) a battleground, for the Siamese's chief enemy, the Burmese, lay to the west, and their

secondary enemy, the Khmer, could more easily be approached via the open corridor to the east of Bangkok.

Although the Thai kingdom in the Chao Phraya plain became the strongest, the Lao living along the Mekong (to whom the Northeast was most accessible) governed the region. In general, amicable relations existed between the empires of Lan Xang and Siam, with the weaker occasionally paying tribute to the stronger. But by the middle of the eighteenth century the Lao empire of Lan Xang had broken in two, the capital of the northern Lao state remaining in Luang Prabang and that of the southern Lao state being established in Vientiane. Both states continued to pay tribute to the Siamese, but in the case of the southern Lao state this was not sufficient. Drawn by the relative nearness and weakness of the latter, the Siamese began to exert greater control. For the remainder of the eighteenth century they were content to govern through the agency of the ruling Lao prince, but in 1831 they took physical possession. Marching through the country, devastating it as they went, the Siamese army captured and deposed the prince in Vientiane. The lands of the southern Lao state were incorporated in the Siamese kingdom and its administration was directed from Bangkok.

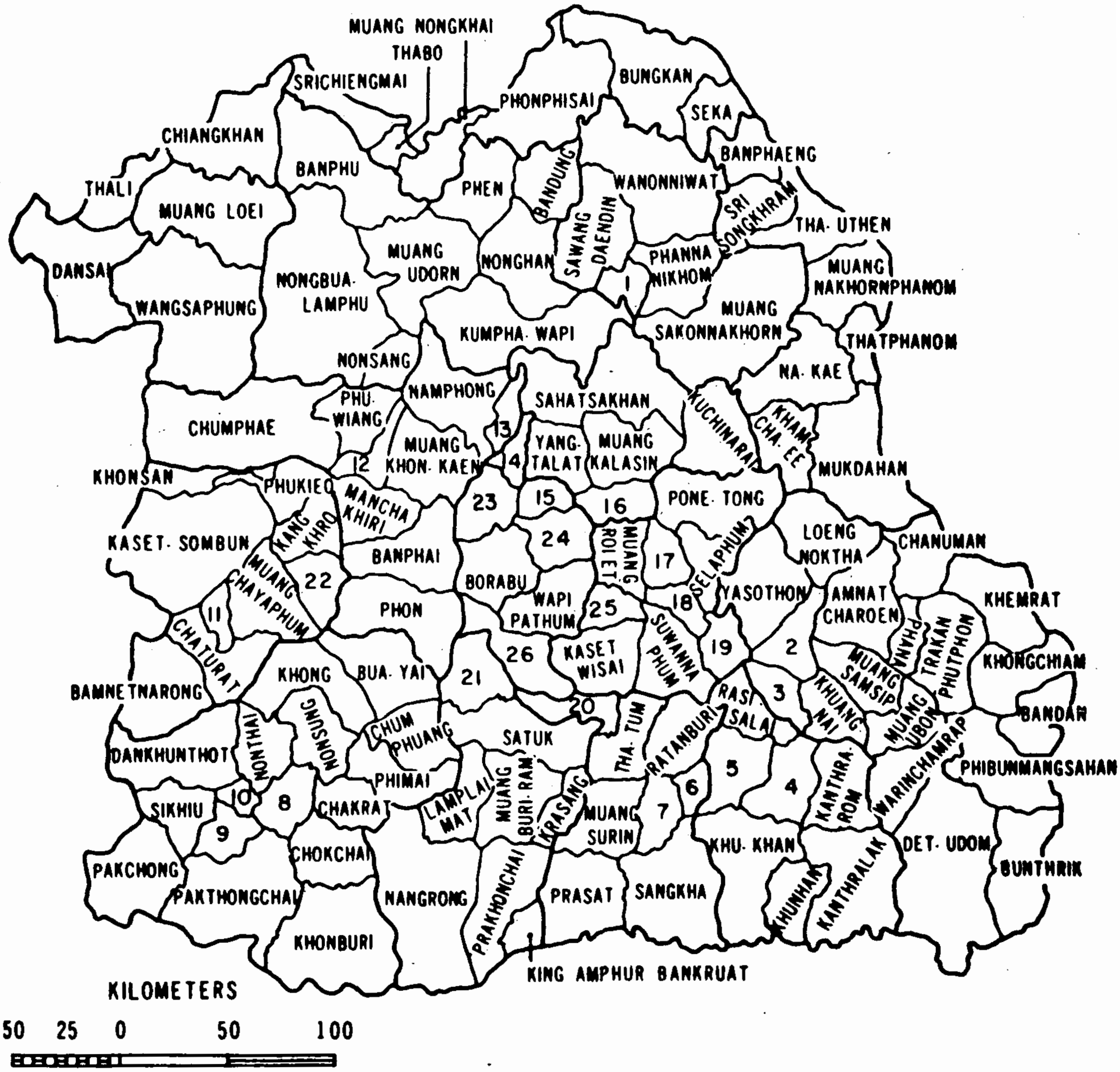
Although at first the territory was governed in a haphazard fashion, the latter half of the nineteenth century saw its administration being rationalized. In 1892, under King Chulalongkorn, control was centralized, the organization assuming the hierarchal form of provinces (changwats, see Fig. 2) that still exists today. These are run by the Ministry of Interior and administered by governors who hold their positions as members of the Civil Service rather than as semi-hereditary chiefs. Provinces are in turn subdivided into districts (amphurs, see Fig. 3), whose administrators are also appointed from the central authority. This authority ceases at the level of the district; the smaller units -- the communes and their component villages -- nominate their own representatives.

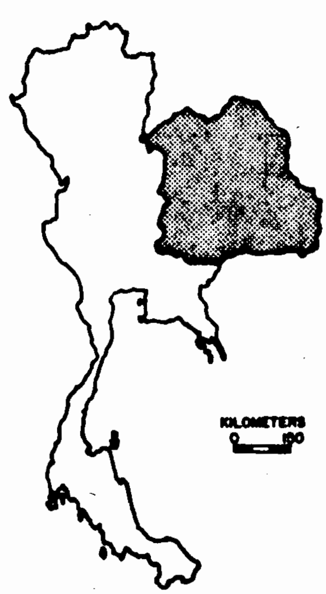
Along with the reorganization of the administrative structure went a reallocation of functions, principally that the Ministry of



1. ANG THONG
2. AYUTTHAYA
3. BURIRAM
4. CHACHOENGSAO
5. CHAINAT
6. CHAIYAPHUM
7. CHANTHABURI
8. CHIANG MAI
9. CHIANG RAI
10. CHON BURI
11. CHUMPHON
12. KALASIN
13. KAMPHAENG PHET
14. KANCHANABURI
15. KHON KAEN
16. KRABI
17. LAMPANG
18. LAMPHUN
19. LOEI
20. LOP BURI
21. MAE HONG SON
22. MAHA SARAKHAM
23. NAKHON NAYOK
24. NAKHON PATHOM
25. NAKHON PHANOM
26. NAKHON RATCHASIMA
27. NAKHON SAWAN
28. NAKHON SI THAMMARAT
29. NAN
30. NARATHIWAT
31. NONG KHAI
32. NONTHABURI
33. PATHUM THANI
34. PATTANI
35. PATTHALUNG
36. PHANGNGA
37. PHET BURI
38. PHETCHABUN
39. PHICHIT
40. PHITSANULOK
41. PHRA NAKHON
42. PHRAE
43. PHUKET
44. PRACHIN BURI
45. PRACHUAP KHIRI KHAN
46. RANONG
47. RAT BURI
48. RAYONG
49. ROI ET
50. SAKON NAKHON
51. SAMUT SAKHON
52. SAMUT SONGKHRAM
53. SAMUT PRAKAN
54. SARA BURI
55. SATUN
56. SING BURI
57. SISAKET
58. SONGKHLA
59. SUKHOTHAI
60. SUPHAN BURI
61. SURAT THANI
62. SURIN
63. TAK
64. THON BURI
65. TRANG
66. TRAT
67. UBON
68. UDON THANI
69. UTHAI THANI
70. UTTARADIT
71. YALA

Fig.2—Provinces (changwats) of Thailand





1. WARITCHAPHUM
2. KHAMKHUANKAEO
3. MAHACHANACHAI
4. MUANG SRISAKET
5. UTHUMPHONPHISAI
6. SAMRONGTHAP
7. SRI-KHORAPHUM
8. MUANG NAKHORNRATCHSIMA
9. SUNGNOEN
10. KING AMPHUR KHAMTHALESO
11. BANKWAO
12. NONGRUA
13. KRA-NUAN
14. CHIANG-YUN
15. KANTHARA-WICHAI
16. KAMALASAI
17. TAWATBURI
18. ARTSARMART
19. PHANOMPHRAI
20. CHUMPHONBURI
21. PHUTTHAI-SONG
22. KHONSAWAN
23. KOSUMPHISAI
24. MUANG MAHASARAKHAM
25. CHATURAPHAKPHIMARN
26. PHAYAKKHA-PHUMPHISAI

Fig. 3—Districts (amphures) of the Northeast provinces

Finance was given fiscal powers that formerly belonged to provincial governors. Other ministries were required to deposit their funds with the Minister of Finance and to give him a periodic accounting of expenditures. In the middle of the nineteenth century taxes had been collected either by the provincial governor or by local residents, usually Chinese, who had purchased the office. Fixed amounts were sent to Bangkok, and the balance was retained by the collector for his own services. After the reorganization, taxes were collected by civil servants, who in turn were paid from general administrative funds. Tax collection thus became more uniform and more general.

In theory, by the end of the nineteenth century the whole of Thailand was administered by a modern bureaucracy organized along functional lines with delegated responsibilities. But as the distance from Bangkok increased, the authority of the central government decreased. Most of the Central Plains were accessible through the network of canals and rivers; Northern Thailand could be reached in the monsoon season by water, although with more difficulty in the dry season. The peninsular east coast of Thailand was accessible by sea and the west coast by an additional journey across the isthmus. But the Northeast of Thailand was very remote, and consequently the representation of the government quite limited. So long as there were no strong states to the east, this did not overly worry the Siamese, but with the arrival of the French, who consoled themselves for their ejection from India by infiltration into Indochina, the Siamese saw the eastern part of their kingdom threatened. In 1893 the French established their protectorate over Laos and within a few years they had forced the Siamese to relinquish their claims to all the land east of the Mekong, as well as a mountainous portion to the west of the Mekong and to the south of Luang Prabang, and the two westernmost provinces of Cambodia.

Fearing further encroachments, the Siamese tried to consolidate their control over the remaining provinces in the Northeast. Communication with the Northeast was very slow, requiring a journey of several weeks by horse, bullock, or elephant up over the escarpment

and down to Khorat, and from there to the frontiers. The Siamese built Thailand's first long distance railroad, completing the 165-mile portion from Bangkok to Khorat in 1901 [3, p. 289].* Until 1926, when the railway was extended to Ubon,** the capital of the south-easternmost province, travel east and north of Khorat was still only possible by bullock carts or, during the few months when the Mun and Chi rivers were in flood, by boat. In the 1930s, the railroad was also extended north from Khorat, reaching Udon Thani before the second World War, and Nong Khai, on the Mekong River across from Vientiane, afterwards. In recent years an all-weather road has been constructed parallel to the railroad from Bangkok to Nong Khai, providing an alternate route to Laos.

As the region became more accessible, the Siamese extended their administration beyond the collection of taxes. With larger staffs the district officials were able to take on more duties, concerning themselves with policing, health, agriculture, transportation, and communications. The inhabitants, formerly little affected by the activities of the central government of Bangkok except when it waged war or levied imposts, became more aware of national authority. Contacts with their relations living in Laos became subject to control by the border police, the western migration of the less civilized tribes was reduced, and, through the school system, conformity to the culture of the Central Plains was imposed. Although of the same linguistic family as the Siamese, the Lao-Thais of the Northeast had used the Cambodian script. In the schools, however, the Bangkok-educated teachers spoke their own dialect and imposed their script. In recent years, to make the Northeasterners feel they were members of the Thai state and to reduce the sense of kinship with the Lao in

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*Numbers in brackets are keyed to the references shown in the Sources at the end of this Memorandum.

**This line passes through the capitals of the three intervening provinces, each lying south of the Mun River on the land above the flood plain, and remains, today, the only rapid means of ground transport through the southernmost provinces.

the north and east, the Thais have even attempted to bring the presence and authority of the state into the countryside. Rural development teams, dispensing medicine, propaganda and entertainment [4], and Mobile Development Units (consisting of about one hundred men directed by an army officer) have undertaken projects in sanitation, water supply, irrigation, agriculture, education, health, and transportation [5, p. 270] in many of the villages.

Knowledge of outside conflict has also penetrated the Northeast. During World War II the Siamese seized those portions of Laos and Cambodia that the French had forced them to relinquish a half century earlier, only to lose them immediately after the cessation of hostilities. And while Thailand was extending its boundaries under the protection of the Japanese, there was local dissension in the Northeast which, although mild and unsuccessful, did help create a separatist spirit in the region.

Despite the poverty of the region, events are making the Northeast of Thailand known and contested. This is not surprising, given the curious nature and setting of contemporary struggles. For the border provinces of the Northeast are as close to the Plaine des Jarres and to the Gulf of Tonkin as they are to the city of Khorat (the ancient name of Nakhon Ratchasima), which gives the plateau its name. Bangkok is twice as far away.

Because of the war in Vietnam and the threat of further insurgency locally, the isolation of the Northeast is now ending. Seven thousand mobile border guards are garrisoned in the provinces lying along the Mekong, and a paramilitary force of rural police is being built up to a strength of 32,000 men [5, p. 270]. Rumors of the struggles in Laos and Vietnam pass through the villages, occasionally accompanied by weapons, deserters, and agitators. Three large air bases, at Khorat, Ubon, and Udon, jointly staffed by American and Thai Air Force personnel and accommodating jet planes, appear as fortresses in the country [5, p. 123]. Twenty-five years of warfare in the countries lying to

the east of the Khorat plateau, and the Northeast's position as a buffer between these struggles and the rich and peaceful basin of the Chao Phraya, have led to its taking on the appearance of an armed camp.*

PRESSURE OF POPULATION ON LAND

The Northeast may be a buffer, but the author believes that this function will be less important in the future than as a reservoir of population. That unemployed Northeasterners represent both a prospect and a problem will be the theme of the remainder of this section. Two motifs, one counterposed against the other, establish the theme: one is the rapid increase in the population of the region, the other is the equally rapid exhaustion of virgin land.

Were the Lao-Thais of the Northeast not agriculturalists, the exhaustion of the stock of free, tillable land would not be such a portent of unemployment. But for centuries the Northeasterner has been accustomed to extending cultivation whenever population has produced pressure on the existing land. The pattern is a congenial one: whenever the population of a village outstrips the land lying conveniently close, the more mobile villagers, usually the young, emigrate in search of unoccupied land. Finding suitable territory, these emigrants then establish a settlement and cultivate the surrounding estate. If there is empty land suitable for cultivation near the emigrants' native village, it is preferred. In this case, the new village tends to grow slowly, remaining a satellite of the old. If there is no empty land nearby, the emigrants will move on to the next amphur, province, or even region.

This pattern of extending cultivation is revealed in a recent study of part of an amphur in the province of Udornthani [57, pp. 297-302]. The first settlers had come in 1667 from the province of Khon

*It reminds one of the Marches, those border areas between medieval England and Wales. Studded with fortresses, garrisoned with English troops and commanded by nobles who were always loyal to their own interests and usually to their king's, the Marches protected the wealthier part of the kingdom from incursions from the poorer.

Kaen, immediately to the south of Udornthani, and had founded the planetary village of Pho. For two centuries thereafter the lands surrounding Pho were adequate for its populace, but the middle of the nineteenth century saw the establishment of its first satellite village, Noi (see Table 1). A second satellite was established in 1924, and a third in 1959.

Of the eleven planetary villages, all but one had been established by 1893, and the last by 1914. The rate of establishment of satellite villages rose from one for the decade 1895-1905, to four each for the decades 1905-1915, 1915-1925, and 1925-1935, and to five each for the decades 1935-1945 and 1945-1955. By 1955, however, almost all the tillable land in the <u>amphur</u> had been occupied, and the decade 1955-1965 saw the establishment of only one more satellite village.*

The same pattern was revealed on a grand scale for the Northeast as a whole through answers to questions in the Population Census of 1960 concerning the province of origin of the inhabitants of the Northeast (see Figure 4 and Table 2), and in a comparison of this census with that of 1947 (see Table 3). Migration between provinces was substantial; 703,418 persons, or roughly one in ten of the population, had moved from one Northeastern province to another within their lifetime. Movement within a single province, such as occurs with the establishment of satellite villages, would boost the number of migrants still higher.

But what is it in these figures that leads to the suspicion that the stock of virgin land in the Northeast is nearing exhaustion? It is that Udornthani province, containing the <u>amphur</u> in which new villages are no longer being established, is one which, on balance, people have lately moved <u>into</u> rather than <u>out of</u>. Had there been land available in other provinces, one would have expected a new emigration from Udornthani; as it was, there has been a net immigration. Part of the influx

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*References to shortages of land appear in almost all studies of Thai agriculture; see for example [229, p. 150; 376, pp. 134-136; 383, pp. 31-33; and 136, p. 69].

Table 1

TYPICAL SEQUENCE OF SETTLEMENT OF VILLAGES IN THE NORTHEAST
(AMPHUR MUANG UDORN)

Planteary Villages and their Satellites	Reported Founding Date	Province of Origin of First Settlers
Pho	1664	Khon Kaen
Noi (or Non Daeng)	1864	
Sang Phrai[a]	1924	
Chiang Pheng	1764	?
Nong Thong	1904	
Kan	1764	Ubon
Kha	1932	
Na Aeng	1766	Khon Kaen
Sok Kae	1922	
Non Lao/Sang Paen	1764 or 1814	Korat/Srisaket
Hin Ngom	1934	
Na Khae	1939	
Non Yang	1943	
Non Klang	?	
Chum	1814	Ubon
Thin	1914	
Phia	1839	Nong Khai
Dong Han	1957	
Nong No	1884	Loei
Dong Mak Lot	1948	
Chiang Yun	1893	Nong Khai
Nong Nam Khem (Old)	1914	(near Vientiane)
Nong Lot	1924	
Champa	1934	
I Rung	1942	
Dong Khwang	1942	
Nong Nam Khem (New)	1944	
Nong Pet[b]	-	
Bo Noi[b]	-	
Nong Paen	1893	Nong Khai/Ubon
Tan Kon	1929	
Han Thao	1914	Ubon
Phak Kat Ya	1954	

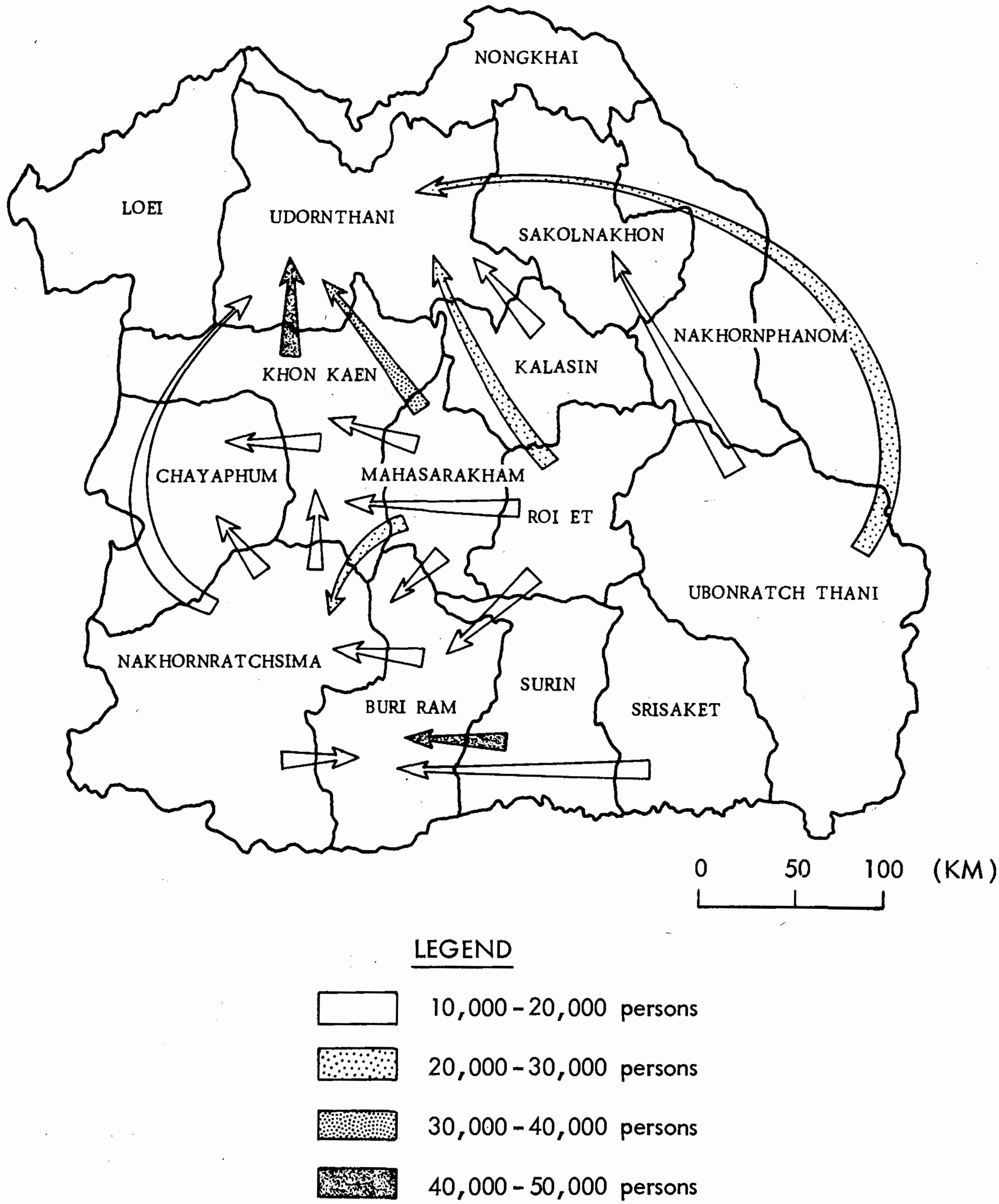
<u>Notes</u>:

[a]A third satellite village, the location of which was not known to investigators, was said to have been established in 1959.

[b]These villages were located outside the study area.

<u>Source</u>:

Ref. 57, Tables 30 and 32, pp. 298-299 and 301.



Source: Data underlying col. (1) of Table 2

Fig.4—Direction of migration between provinces in the Northeast during the lifetime of those resident in 1960

Table 2

EMIGRATION AND IMMIGRATION FROM AND TO THE NORTHEASTERN PROVINCES WITHIN THE LIFE SPAN OF THE POPULATION ALIVE IN 1960

Province	Emigration to Other Provinces in Northeast	Emigration to Other Regions			Total Emigration	Immigration	Net In- or Out-Migration
		North	Central Plain	South			
Mahasarakham	119,480	235	7,218	357	127,300	23,734	-103,566
Roi-Et	101,841	1,067	18,301	1,387	122,596	35,099	- 87,497
Surin	59,187	98	11,823	1,215	72,322	30,406	- 41,916
Srisaket	38,426	--	11,928	3,492	53,846	25,091	- 28,755
Ubon	86,688	1,010	21,299	5,122	114,118	44,653	- 69,465
Kalasin	31,633	153	5,104	100	37,026	27,798	- 9,228
Khon Kaen	91,330	290	10,778	1,078	103,477	96,243	- 7,234
Nakhornphanom	16,192	169	2,469	244	19,074	15,014	- 4,060
Chaiyaphum	18,175	1,910	9,379	441	29,905	62,073	32,168
Korat	65,730	2,061	41,827	1,602	111,220	122,305	11,085
Buri-ram	28,497	222	9,574	305	38,598	116,759	78,161
Loei	5,170	42	833	--	6,045	9,070	3,025
Sakolnakhon	13,702	--	1,633	--	15,335	41,753	26,418
Nong Khai	7,098	--	1,190	57	8,345	45,728	37,383
Udon	20,259	--	4,426	--	24,685	218,447	193,762
Whole Northeast	703,418	7,257	157,818	15,401	883,892	914,173	30,281

Source:
Ref. 200, Table 3, p. 24; determined by comparing province of birth with province of residence in 1960.

Table 3

DIFFERENTIAL RATES OF POPULATION INCREASE AND ESTIMATED RATES OF NET MIGRATION FOR PROVINCES IN THE NORTHEAST, 1947-1960

Provinces (Changwats)	Population 1947	Population 1960	Annual Rate of Population Increase 1947-1960 (percent)	Estimated Rate of Net Migration[a] (percent)
Mahasarakham	397,710	499,373	1.7	-1.1
Roi-Et	536,279	668,193	1.7	-1.1
Srisaket	472,378	601,356	1.8	-1.0
Ubon	856,373	1,130,712	2.1	-0.7
Surin	438,771	581,732	2.2	-0.6
Kalasin	312,936	426,795	2.4	-0.4
Nakhornphanom	313,953	436,482	2.5	-0.3
Khon Kaen	590,638	844,075	2.7	-0.1
Loei	136,161	210,535	3.3	0.5
Sakolnakhon	270,472	426,755	3.4	0.6
Korat	731,722	1,094,774	3.5	0.7
Chaiyaphum	291,598	486,472	3.9	1.1
Buri-ram	334,561	583,585	4.2	1.4
Nong Khai	144,240	256,530	4.3	1.5
Udon	386,116	744,174	4.9	2.1
Entire kingdom	6,213,908	8,991,543	2.8	

Note:

[a]Assuming a natural rate of increase of population of 2.8 percent per year in each province. Thus the figures in the last column are equal to the figures in the next-to-last column minus 2.8 percent.

Source:

Ref. 200, Table 2, p. 21; 382, Table B-6, p. 448.

was people moving to the province's capital, Udorn, which grew in population to 29,965 in 1960. Since Udorn city is located within the amphur Muang Udorn, its growth may have accounted for some of the immigration into that amphur, not for the immigration (193,762; see Table 3) into the entire province; at least some of the immigrants must have been drawn by the lure of land. If there is little virgin land in the province to which migrants were attracted, then there must be even less in those provinces from which they departed.*

Had the soil of the Northeast been surveyed one might be able to say that so and so many rai** were tillable and that such and such a portion of this was not yet under cultivation. But soil surveys have not yet been carried out over any large area [200, p. 6], so the portion still to be exploited is difficult to determine. In all of Thailand, the government estimates that there are 120 million rai of tillable land, of which 70 million are already being cultivated [327, p. 7]. In the Northeast, the proportion of tillable land actually being cultivated is probably higher, and the remainder still to be brought under cultivation lower than in the country at large [200, pp. 6-7].

Other indications that in the Northeast little fertile land remains still unclaimed are given by the average holdings, yields and, by inference, incomes from agriculture. In brief, Northeasterners possess and cultivate less land, and derive lower yields from it, than do the farmers in the Bangkok Plain. Table 4 reveals that the amount

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*Corroboration is provided by two agronomists, one of whom observed that during the decade 1952-1961 there were deficits of rice production over local consumption in the provinces of Loei, Srisaket, Surin and Nakornratsima [200, p. 62], and the other of whom added Buriram, Roi-et, and Mahasarakam (mentioning Sakonnakon and Udornthani as two with surpluses) [391, pp. 30-31]. An agricultural economist [382, pp. 122-123] calculated that eleven of the fifteen provinces in the Northeast (but not Udornthani) were in occasional or persistent deficit.

**A rai is the customary unit of area, and is equal to 0.3954 acre; just a little more than two and one half rai make an acre.

Table 4

CULTIVATED LAND PER CAPITA, RICE YIELD, AND PERCENTAGE OF LAND DEVOTED TO RICE PRODUCTION, FOR PROVINCES IN THE NORTHEAST AND THE BANGKOK PLAINS, 1960/1962

Northeast			
Province	Cultivated Land per Capita (rai)	Rice Yield (kg/rai)	Land Devoted to Rice (percent)
	(1)	(2)	(3)
Chaiyaphum	2.1	236.7	88
Nakomratsima	2.4	196.1	80
Buri-ram	2.6	161.0	97
Surin	2.9	174.3	99
Srisaket	2.3	118.9	100
Ubonratthan	2.8	141.7	98
Nong Khai	1.9	236.2	97
Loei	0.9	298.7	77
Udornthani	2.5	238.3	94
Sakolnakhon	2.3	202.3	98
Nakhornphanom	1.5	196.5	96
Khon Kaen	2.5	197.3	88
Mahasarakham	3.1	141.7	90
Kalasin	2.3	180.0	95
Roi-Et	2.8	115.5	97
Simple Arithmetic Average	2.3	189.0	93

Bangkok Plains			
Province	Cultivated Land per Capita (rai)	Rice Yield (kg/rai)	Land Devoted to Rice (percent)
	(1)	(2)	(3)
Chainat	3.8	291.4	94
Sing-Buri	3.5	310.9	98
Lop Buri	4.6	254.7	62
Sara Buri	4.0	322.8	76
Ang Thong	3.1	260.2	99
Ayutthaya	5.1	226.2	100
Nonthaburi	2.2	312.1	99
Pathum Thani	6.8	265.6	99
Thon Buri	0.9	291.4	94
Phra Nakhon	2.7	281.0	100
Nakhon Nayok	5.5	172.2	100
Samut Prakan	2.6	378.1	100
Nakhon Sawan	4.1	257.9	75
Suphan Buri	4.2	201.6	94
Nakhon Pathom	3.1	297.3	92
Samut Songkhram	0.3	217.1	61
Samut Sakhon	2.5	348.9	91
Simple Arithmetic Average	3.5	275.6	80.7

Sources:

Column (1): Ratio of land in field crops (including rice) to population living in agricultural households, 1960/1962 (rai per person), [382, Table III.2, pp. 85,86] calculated from the 1963 Agricultural Census [329] and the 1960 Population Census [326].

Column (2): Average yield of rice in 1962, kilograms per rai [382, Tables A-1 through A-32, pp. 404-418] calculated from the primary sources [321, 395, and 396].

Column (3): Percentage of all cultivated land devoted to rice in 1962 [382, Table IV-2, pp. 118, 119] calculated from the primary source [329].

of cultivated land per person supported by agriculture varies from 0.9 rai in Loei to 3.1 rai in Mahasarakam, with a simple arithmetic average of 2.3 rai for the entire 15 provinces. In the Bangkok Plain, the range is from 0.9 rai to 6.8 rai per person, and the average is 3.5. The range of rice yields in the Northeast is from 115.5 kilograms per rai in Roi-et to 298.7 in Loei, with an average of 189.0; the range in the Bangkok Plain is from 171.2 to 378.1, with an average of 275.6.* Since rice production per capita is the multiple of the number of rai cultivated and the yield per rai, the difference in returns between the two regions is even more pronounced. Assuming that the yields of other crops vary as does that of rice, production per capita in the Northeast is only 45 percent of that in the Bangkok Plains (435 vs. 964 kilogram-equivalents per capita). Since the income of farm families comes almost entirely from the crops they raise, per capita income in the Northeast would tend to fall short of that in the Bangkok Plains by the same proposition.**

The preceding evidence of the scarcity of fertile land in the Northeast, at least relative to the better endowed region around Bangkok, speaks only of a single year. What is perhaps more revealing are the trends within the Northeast itself -- in essence that new land is being brought into cultivation at a decreasing rate while population is growing at an increasing rate. These trends, derived from the data in Table 5, are displayed in Fig. 5, in which both the land under cultivation to rice and the population are plotted for three separate years over a 25 year period. The vertical scales, one for each variable, are logarithmic so that constant rates of growth will be translated into straight lines. The curve through the period of time that

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*There appears to be an inverse relation between the size of the holding and the yield for both regions; in a comparison of the two, however, the land in the Bangkok Plains yields more abundantly than that in the Northeast. The margin of cultivation seems to have been pushed further, into less fertile land, in the Northeast.

**In 1963, net income per holding (calculated as gross income less expenses) in the Northeast was, on the average, 2,407 baht; in Thailand as a whole it was 5,913 baht ([605], quoted in [606, Tables 94 and 95, pp. 187 and 188]).

Table 5

POPULATION OF THE NORTHEAST AND LAND UNDER RICE CULTIVATION,
BY PROVINCE, VARIOUS YEARS 1937-1962

Province	Population			Land Under Cultivation (Thousands of rai)		
	1937	1947	1960	1937	1950	1962
Chaiyaphum	237,214	291,598	486,472	228.4	501.0	938.9
Nakomratsima	598,503	731,722	1,094,774	517.4	822.6	1,407.4
Buri-Ram	240,338	334,561	583,585	197.3	496.3	1,082.6
Surin	338,840	438,471	581,732	424.7	935.0	1,425.8
Srisaket	363,862	472,378	601,356	520.4	933.1	1,346.9
Ubonratthan	744,836	856,373	1,130,712	1,272.2	2,554.7	2,931.3
Nong Khai	115,441	144,240	256,530	138.3	292.7	433.6
Loei	113,120	136,161	210,535	123.6	101.3	130.1
Udornthani	262,856	386,116	744,174	263.1	1,006.5	1,365.3
Sakhon Nakhon	212,529	270,442	426,755	281.0	801.9	993.8
Nakhon Phanom	247,403	313,953	436,482	284.7	514.0	555.2
Khon Kaen	475,516	590,638	844,075	502.4	709.7	1,392.1
Mahasarakham	570,648[a]	394,410	499,373	709.5[a]	627.4	1,165.1
Kalasin		312,936	426,795		1,034.9	956.0
Roi-Et	431,192	536,279	668,193	692.3	1,363.1	1,695.6
Total	4,952,288	6,210,278	9,021,543	6,155.3	12,694.2	17,819.7

Note:

[a]Observations missing [382, footnote 10, p. 244]; estimate based on average number of rai cultivated per person in all other provinces.

Sources:

[382, Table B-6, p. 448, for the 1937, 1947, and 1960 Population Censes; and Tables A-1 through A-33, pp. 404-410, for land under rice cultivation. 1950 and 1962 were years of Agricultural Censes; 1937 the earliest year for which figures were given.] The primary sources were [321], [395], and [396].

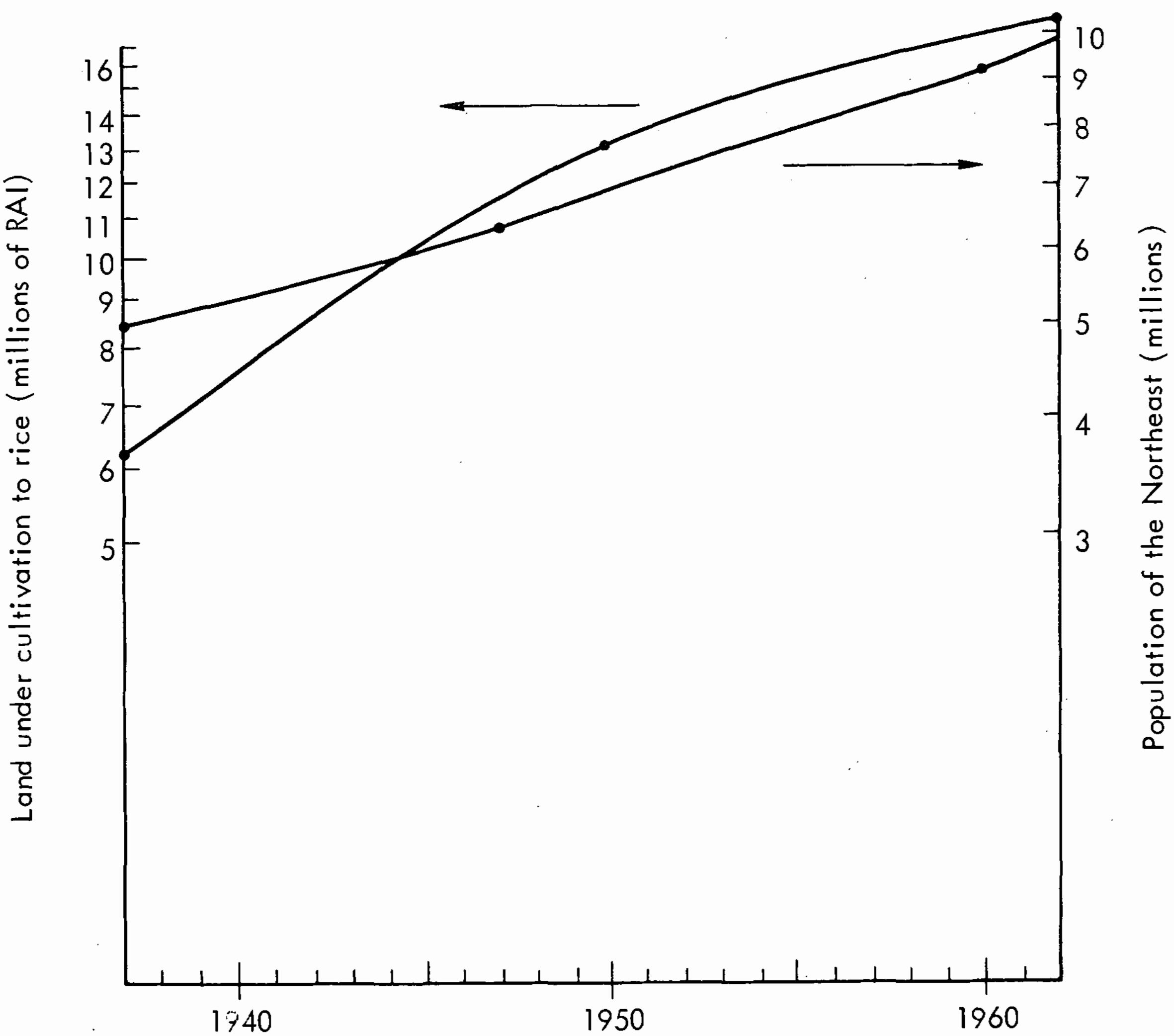

Fig. 5—Population and land under cultivation to rice in the Northeast, 1937-1962

Source: Table 5.

land was under cultivation to rice* is noticeably concave downwards, and that of population slightly concave upwards, illustrating the divergent trends. The ratio of quantity of cultivated land per person reached its maximum about 1953. Allowing for the (probably) lower fertility of land more recently brought under cultivation, the ratio corrected for the quality of land would have reached its maximum still earlier.

POSSIBILITIES FOR ALLEVIATING THE PRESSURE

Our thesis is that population in the Northeast of Thailand is growing faster than land is being brought into cultivation and agricultural output is being expanded. As a consequence of the pressure of population on natural resources there may be, singly or jointly, any of several responses. The first is the passive acceptance of economic scarcity, and perhaps a redirecting of human energies and talents to spiritual matters. In its quietistic philosophy Buddhism provides the principles and (in its ubiquitous temples) the institutions by which an increasing fraction of the population could reduce their demands upon the economy. Consumption and production would give way to meditation, and unemployment to withdrawal from the labor force. This response appears to the author to be suitable for a few but not for many: there does not seem to be enough of a productive surplus to support large numbers in this state.

A second possible response would be for the Northeasterners to remain actively on the land, adapting their agricultural techniques to the changing resource pattern. In some countries, the pressure of population on land has led to its more intensive cultivation. In Java, for example, rice cultivation is increased by the techniques of "... pre-germination, transplanting, more thorough land preparation, fastidious planting and weeding, razor-blade harvesting, double cropping, and more

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*As column three of Table 4 shows, almost all of the cultivated land in the Northeast (93 percent on the average in 1962; slightly larger percentages in 1937 and 1947) was planted in rice, so the curve for all cultivated land would have the same shape.

exact regulation of terrace flooding" [392, p. 77].* It is very difficult to tell from the available evidence if the Northeasterners would be likely to change their ways of working. Ever since leaving China, the Thais have found virgin land readily available. Consequently, their methods of cultivation have been determined by the type of field, that is, whether or not it is irrigated, how closely it lies to the village, and so forth, rather than by the land-to-labor ratio. Fields apparently will be cultivated in the traditional manner, even when the population in the village or the total amount of land being cultivated changes [376, pp. 294, 311, 341].

But this custom of moving on, whenever the village land was already supporting the usual number of families applying the customary techniques, might lapse if it were found to be profitable to employ additional labor. "Profitable" in this sense meaning perhaps providing a status and yielding a return to the extra worker equal on the average to that achieved by those already employed. It does not seem likely that many profitable opportunities will arise automatically within the villages -- habits and customs adapt slowly even when resources are under great strain -- but they may be created with outside assistance. The Thai government is the obvious agent, for it could provide all the ingredients of change such as seeds, fertilizers, irrigation, instruction and demonstration, transport, storage, credit, and so on. Such multifarious government investments in agriculture are doubling and trebling yields of wheat in West Pakistan and rice in the Philippines [479].

The increase could be substantial, but equally substantial would be the investments, the size and skill of the government organizations, and the duration of time necessary to achieve the results. The requirements, as successful agricultural extension programs reveal, are

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*Similar labor intensive techniques used in cultivating rice in other countries are cited in [393, p. 122; and 394, pp. 78-100]. As column three of Table 4 shows, almost all the cultivated land in the Northeast (93 percent on the average in 1962; slightly larger percentages in 1937 and 1947) was planted in rice.

measured not in thousands of dollars but in millions, not in individual agronomists and engineers and teachers and administrators but in teams of hundreds, not in days or months but in years. If the potential for expansion of opportunities in the traditional sector is great, so are the difficulties in realization.

Some Northeasterners may relieve the pressure on the land by moving to the towns and cities. Bangkok has already drawn many,* as have, more recently, the provincial capitals of Khorat, Ubon, and Udorn. This movement will be more pronounced the more rapid is industrialization and the less rapid is agricultural development. Encouragement of industrialization by the Thai government would both increase the immigration to the cities and augment its benefits.

Other alternatives for the Northeasterners suggest themselves: the available work may be shared among more persons, each participant contributing less to the expanded household and drawing less from its combined output. Although the creation of underemployment of labor in itself would represent a change in Thai customs through the redefinition of activities and reallocation of tasks, it has happened so often in other underdeveloped countries that it cannot be discounted. For the discontented Thai, more ambitious and active alternatives must also be considered, such as political organization, agitation, protest, and rebellion.

As this is a quantitative study conducted by an economist, its attention is directed towards economic phenomena: the religious and political alternatives are not considered explicitly. In the next section the methods by which the economic alternatives might be evaluated are discussed and the choice of one specific method defended.

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*The majority of the 157,818 persons who have emigrated from the Northeast to the Central Plains (see Table 2, column 3) have settled in the nation's capital.

II. METHODOLOGY

The argument in the previous section can be summarized in two questions: By what means might the inhabitants of the Northeast earn their livelihood in the future? and, What outside efforts would be necessary to provide sufficient means for all? A third question, What might happen if the means of support were not available? remains ominously in the background.

Questions tend to shape answers, and so do methods of analysis. In our analysis the method to be applied -- simulation -- is a complex one, capable of providing detailed answers. It is a relatively new technique, no older than the electronic computer and the study of engineering systems, and so its applications are not familiar and its procedures are not standardized. Its potentialities as a method of analysis in economics are great, once the difficulties in evaluating its quick results can be overcome.

The simulation exercise proceeds much as any other quantitative technique in economics, commencing with a careful formulation of the hypotheses. When hypotheses or ideas are precisely stated and related to one another the assemblage is called a model: most precise of all is a mathematical model, not because it is the only logical form but because it is the most explicit and the least conducive to inconsistency. Hypotheses are not complete until the relations between the variables are specified over the entire range of possible values, which an equation does simply and economically.

What characteristics should our model have? First it should include that phenomenon upon which we are focusing, the better to understand it. Already a difficulty arises, for it is usually hard, and occasionally impossible, to capture quantitatively all the dimensions of a phenomenon. If, as we have argued in Section I, unemployment is an important phenomenon, we must concoct a measure of its extent. Presumably the larger the number of persons looking for work at any instant, the more widespread is the phenomenon; this is the measure we use. But it omits those who have despaired of finding

employment and consequently turned to some other activity. It neglects the composition of those who are unemployed: their ages, sex, education, abilities, aspirations, and so on. It fails to consider how long they have been unemployed, the types of work for which they are fitted, the types they have been seeking, the types they are likely to find. Unemployment is multi-faceted and a count of unemployed persons is a measure along only one facet.

Second, the model should contain all the important factors, important in the sense that within their expected ranges of values they have a noticeable effect upon the phenomenon one is trying to understand. Here again arises the difficulty of measurement and the risk of exclusion. Importance is at first determined subjectively and almost always by the person who formulates the model. He will draw upon the knowledge of others, incorporating those factors that he has been persuaded are consequential. If he is uncertain as to the relative importance of different factors he may consider alternatives, developing as many models as he admits possibilities. But the initial formulation, or formulations, is still subjective, and it is this subjectivity that accounts for what may be the greatest error in model building, not incorrect relationships between factors that are included but omission of factors that should have been included. In including few political factors our model of the economy of the Northeast may incur this error.

Third, the model must specify mathematically the relationships between the phenomenon on which the study focuses and the factors that influence it. Here theory or statistics can be utilized in order to provide some criterion for choosing, among the many possible, that particular form in which the variables are to be connected. What we believe to be the important factors will be identified and interrelated in Sections III through VII.

Any model contains certain constraints or assumptions. (Ours appear in Sections III through VII.) These are also hypotheses, of a limiting or restricting nature, for example, the common assumption of a fixed rate of growth of population. Assumptions and constraints

are useful in simplifying the model, often making analytic solutions possible or permitting argument by analogy to well-known cases. There are the dangers, however, that crucial types of behavior, or ranges of results may be assumed away and that all assumptions may not be recognized or admitted. If the most common error in the formulation of a model is to leave out an important factor, the most common error in its presentation is to leave implicit a vital assumption.

The determination of the implications of any model is an exercise in logic; the consequences flow directly and inevitably from the formulation. There is nothing new in the implications, nothing that is not already contained in the model; it is simply that the deductions reveal the nature of the model. They also may lend themselves more readily to empirical testing than do the original hypotheses.

Testing hypotheses or deductions is a tedious and haphazard activity. The tests that have been designed for simulation models are numerous and inexact, as might be expected when one tries to determine such different things as whether or not the right factors have been included, whether or not they are correctly related to one another, and whether or not the behavior displayed by the model correctly simulates actual behavior. Yet acceptance of a model can come only after it has successfully passed such tests. What may seem to the author a satisfactory test may seem to the reader to be unsatisfactory, and what may seem to the author success may seem to the reader to be failure. In Sections IX, X, and XI we shall discuss the types of tests to which we should like to subject our model, the standards against which we would measure success, and shall carry out those that we can. As this is the first study of the economic development of the Northeast of Thailand it is unlikely that the model can be adequately tested; it is also unlikely that it will survive unscathed the limited testing that we can do. The author will therefore try in the last section to indicate how the analysis may be improved and what further research may be conducted.

Since simulation is not the quantitative technique that would first come to the minds of most economists, we ought to justify its

selection. The choice of technique affects the forms that equations may take and the means by which solutions may be obtained. Ideally we should like a mathematics that would correctly represent the nature of human activities and decisions, that would accommodate the crude data with which we must work, and that would yield analytic solutions -- solutions valid for all possible values of the variables. In practice we must accept considerably less. If analytic solutions are desired, we are generally restricted to systems that are linear and consequently decomposable, or to non-linear systems that are very simple and consequently highly abstract. Examples of techniques with the former characteristics are multiple regression [400, 401, 402], input-output analysis [403, 404, 405, 406], and linear programming [407, 408, 409, 410]; examples of the latter are growth models [411, 412, 413] and game theory [414, 415].

Yet the world is notoriously non-linear and complex. If, above all, we want accurate representations of activities and decisions, we have to relinquish models that yield analytic solutions and content ourselves with the few for which there are algorithms -- rules for solving by repeated sets of calculations* -- or the many for which particular solutions can be obtained. These latter are called simulation models because being large and complex they generate behavior that, hopefully, imitates or simulates that of their real counterparts [see, for example, 418, 419, 420, 421, and 422].

Our choice among these techniques must be dictated by the nature of the environment and the questions that have been raised about it. In the present study the environment can be described as a portion of an underdeveloped country, a region that has never been amply endowed and whose population is now outstripping its resources. Agriculture occupies most of the population, but industry, commerce, and services (including government) will be needed to provide employment in the future. The growth of these non-agricultural activities will require

*Dynamic programming is the chief example. See, for example, [416 and 417].

that part of the population adopt specialized skills and an urban existence. It may also require that capital, knowledge, and enterprise be provided from outside the region. The questions that have been raised are: What part of the population will obtain subsistence in the traditional manner; What part will seek employment in the modern sector; and How great an effort will be needed to accommodate all those desirous of work?

To answer these questions we shall have to construct a model that (1) contains at least two sectors (traditional and modern), (2) identifies the population in its different occupations (in agriculture, in private enterprises in the modern sector, and in public enterprises), (3) specifies other resources that are already in existence or that will have to be provided (land, capital, commodities, and knowledge), (4) recognizes agents of change (private entrepreneurs and government), and (5) relates all of these to one another in ways similar to the ways they are actually related in the Northeast of Thailand.

We cannot expect such a model to reproduce past, or forecast future, behavior perfectly. Random forces, such as weather, influence the real world and cannot be predicted. But we can hope that the model's behavior will approximate experience -- approximate in the sense that its variables assume appropriate absolute values, that the overall trends are correct, and that the phasing is accurate; that is, all variables should have the proper relationships in magnitude and in time.

Because the environment is complex and many of the real relationships appear to be non-linear, and because the time responses seem important, we have rejected multiple regression, input-output analysis, game theory, and both types of programming. Two growth models, those of Ranis and Fei [413] and of Lefeber and Chakravarty [456], describe rather well the environment we are considering and can be solved analytically, but do not admit agents of change. If we wish to estimate the magnitude of the task of providing opportunities for the inhabitants of the Northeast, we must include explicitly the instruments of government, identified in Section VII, that are at hand.

The only technique that will allow us to do all this is simulation. In choosing it we have lost two advantages of most of the other techniques -- analytic solutions revealing general patterns of behavior, and specific solutions indicating optimum allocations. However, we believe that the advantages of greater realism and greater detail will more than compensate for these drawbacks.

Simulation models can be complex, containing many equations and necessitating many calculations. Examples of simulation studies are therefore as recent as the electronic computer, which removed the mathematical constraint on determining results.

The technique of simulation is best described in [423] and [482]. Several simulation models of economic systems have been constructed and analyzed: one was directed to the demographic characteristics of the American population [424]; another to the wholesale lumber market in the West Coast states [425], and yet another to the markets for hides, leather, and shoes in the United States [426]. Several models of actual industrial firms have been designed [427, 428, 429], as well as fragmentary models of typical firms and industries to be used as teaching devices [for example, 430]. Two large-scale regression models of the American economy have been simulated to determine their response to changes in fiscal and monetary policies; see [502] and [503]. There are fewer simulation models to be cited in the other social sciences, although some interesting examples can be found in [431-437] and a bibliography in [615].

For our purposes, the most relevant are models of underdeveloped economies. The best attempt is that of Holland [438, 439, 440], who describes a hypothetical economy and studies the effects of different investment programs and balance of payments policies upon its development. Another such study traces the effects of the migration of labor and changes in the distribution of income upon a different but still hypothetical economy [441]. At present, attention is being directed toward real economies. The most advanced projects include: one on the economy of the United States being done at the University of Wisconsin under the direction of G. Orcutt; of Venezuela, at the

Universidad Central [442]; of Argentina, at the Universidad de Buenos Aires [443] and [504]; and of Ecuador, at Yale University [444].

All these studies of national economies, as well as the present study on the Northeast of Thailand, utilize the same methodology. The models, like the environments they describe, are very complex -- dense mathematical agglomerates; but their formulation is simple, for each equation is conceived separately, and their computation is elementary, for each equation is solved in sequence. Their behavior is revealed step by step, histories being generated as the solutions proceed. The computer makes the calculations, following the instructions that have been submitted to it.* Periodically it memorizes a statistical record of the model's behavior, which it reproduces at the end of the simulation.

The evaluation of complex models is very difficult. Each experience or "run" is likely to vary (bound to if there are random shocks) from all others, to a greater or lesser extent, depending upon the model's sensitivity to changes in the values of different variables, and upon the actual magnitudes of the changes. It is difficult to decide what, if any, are the general patterns of behavior; how well, if at all, it simulates the behavior of the economy it is modeled after; which, if any, are the particularly sensitive variables; and how, if at all, the performance of the system can be improved. We face these difficulties when we try to evaluate the behavior of the model in Sections IX through XI.

Sophisticated as it is, the simulation technique only reveals some of the properties of the system -- properties that were already implicit once it had been formulated. In this sense, only one system is examined. To be sure, new channels may be used, new criteria for decisions selected, or new elements created, but the rules for use, selection, or creation must be specified in advance. This may seem

*A description of the computer program for the simulation of the model of the economy of the Northeast is laid out in Appendix B and a print-out of the equations of the model in Appendix A.

paradoxical, for the purposes of this study are not only to extrapolate economic trends in the Northeast but also to determine the effects of alternative formulations of the model, yet the characteristics of the technique limit one to a system that does not undergo any changes at all. Entirely new (unconceived) types of elements, forms of organization or rules for decisions cannot be attributed to the model; every possible condition must be considered beforehand. Changes are relegated to shifts in the prominence of one or another of the system's components, that is, to shifts in magnitude. It is by varying magnitudes that we try to gain an understanding of the nature and behavior of the model, and hopefully of the economy the model is designed to reproduce.

III. THE MODEL: POPULATION

This section and the four that follow contain the formulation of the simulation model of the economy of the Northeast of Thailand. The present section breaks down the population of the region and analyzes the subgroups; Section IV is concerned with output and employment in the traditional (agricultural) and modern sectors of the economy, and Section V with incomes and expenditures in these two sectors. Section VI attempts to locate the points at which the economic structure of the Northeast is bound to that of the rest of Thailand, and Section VII incorporates the policies by which the national government can promote the economic development of the Northeast.

From this vantage point we cannot focus on the individual, only on groupings. The largest grouping is the entire population of the Northeast. At the time of the census of April 25, 1960, the population was 9,021,543.* Its growth over the next generation is problematic and will occupy our attention first.

To the extent that future population growth can be inferred from the past, the figures in Table 6 are relevant. They indicate some increase in the birth rate up to World War II, and a substantial reduction in the death rate since. The former increase has no single cause; the latter decrease is attributable to the near elimination of malaria. As there appears to be no great incentive on the part of the government to limit population growth, nor desire on the part of parents to have fewer children, we shall not expect any immediate and sizable decline in the birth rate and would not be surprised at a further rise.

The next task is to express mathematically both the historical performance and future prospect of the growth rate. This will involve

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*[326]; included were all individuals residing in the Northeast at the time of the census, less foreign nationals employed by their governments, and the members of a few nomadic hill tribes. Thus, military personnel were included, as were some 60,000 refugees from Vietnam.

a generalization about population growth in a developing country, its translation into a mathematical expression, and its numerical solution for any instant in time.

Table 6

BIRTH RATES, DEATH RATES, AND NET RATES OF POPULATION GROWTH IN THAILAND, VARIOUS YEARS 1922-1962

	Yearly Rate (percent)		
Year(s)	Birth	Death	Net Growth
1922-24	2.77	1.51	1.26
1925-29	2.99	1.55	1.44
1930-34	3.46	1.63	1.83
1940	3.63	1.73	1.90
1954	3.42	.97	2.45
1962	3.48	.79	2.69
1964-65	4.18	1.11	3.07

Sources:
1922-1962 [614]; 1964-1965 [607, Table A, p. 10].

The general growth pattern is assumed to be as follows: the population of a primitive society rises slowly, from a rather low rate (RGPDP), until the society is seized by progress. At this point the growth rate rises more quickly, first at increasing then at decreasing rates, until a peak (MXRGP) is reached. With still greater progress, the growth rate thereafter declines toward a new, again rather low rate (RGPAF).

The three parameters -- RGPDP, MXRGP, and RGPAF -- are typical of the nomenclature we shall use. Capital letters in the Latin alphabet are obligatory, since computers do not recognize any others; and six is the maximum number that can be attached to a variable. The meaning of the variables can be remembered more easily when the letters are mnemonic:

RGPDP = Rate of Growth of the Population Departed from in the Past, fraction per year.

MXRGP = MaXimum Rate of Growth of the Population, fraction per year.

RGPAF = Rate of Growth of the Population Approached in the Future, fraction per year.

All the variables used are listed in alphabetical order in Appendix A, together with their definitions. A list of equations is also included in Appendix A.

Figure 6 graphically displays the trends of the rate of population growth. The curve of the growth rate over time looks something like the profile of a lopsided bell, one of whose rims is elevated above the other by the amount by which RGPDP differs from RGPAF.

There is no simple mathematical formula that will generate the entire curve of Fig. 6, but there is one that can generate half of it. This is the Rayleigh distribution,

$$f(u) = ue^{-1/2(\frac{u}{\sigma})^2}$$

where the density f(u) is the distance to the abcissa of a bivariate normal distribution with standard deviation σ.*

We shall use portions of the Rayleigh distribution on both sides of the mode (that is, on both sides of f(u) = maximum): in Fig. 6 these are the portions drawn in heavy dashed and dotted lines, falling from the peak (MXRGP) toward the asymptotes (RGPAF) and (RGPDP). Over these portions, the variable u is equivalent to time (T). The density f(u) at its mode (set at time T zero, or TO) is equal to MXRGP - RGPAF.

*See [505], [506]. The Rayleigh distribution is equivalent to the χ distribution with $n = 2$ and $\sigma = \alpha/2$; stated in another way the variable $\sqrt{u/n}$ is distributed like χ^2. The author is obliged to A. Klinger for recognizing that it was the Rayleigh distribution that met the requirements of being (half) bell-shaped and integrable.

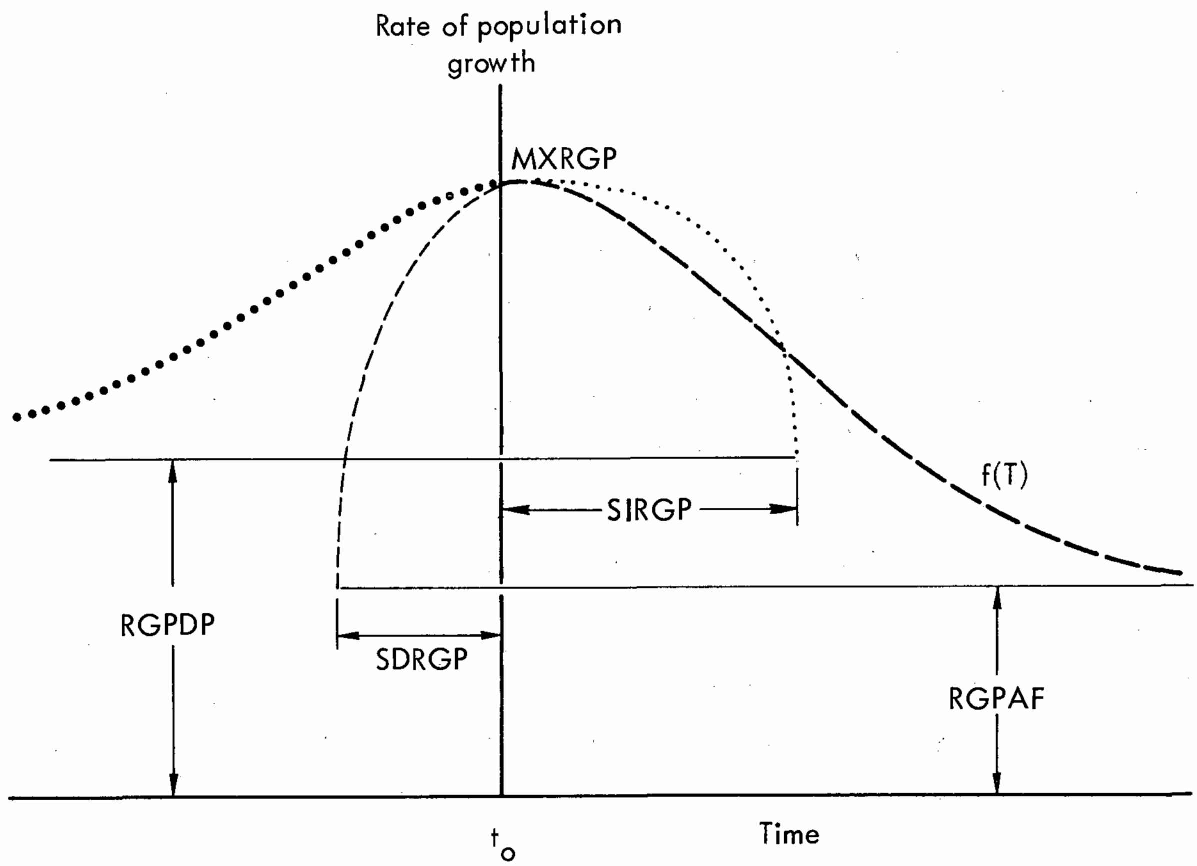

Fig. 6 — Trends in the rate of population growth in a developing region

The variable σ, the standard deviation of the Rayleigh distribution, is the measure of the rapidity with which the growth rate rises or declines to or from its peak: the smaller the value of σ, the swifter the ascent or descent. In our formulation, the standard deviations (SIRGP) and (SDRGP) will reflect two factors -- the exogenous rise or decline in the birth rate that is assumed to occur with the passage of time, and the deliberate change (decline or possibly increase) that a government is able to bring about by its efforts.

The mode of the Rayleigh distribution occurs at a value of u equal to σ. If we wish to use that portion of the distribution to the right of the mode, we must restrain u such that it varies from $+\sigma$ to infinity. Changing variables from u to T yields the expression for the right half, the heavy dashed line, of Fig. 6:

$$f(T) = RGPAF + \alpha(T + SDRGP_i)e^{-1/2\left(\frac{T + SDRGP_i}{SDRGP_i}\right)^2}$$

$$0 \leq T \leq \infty$$

Solving this at T = T0, where f(T) = MXRGP, we obtain the value for the constant α, yielding the complete expression:

$$f(T) = RGPAF + \left[\frac{MXRGP-RGPAF}{(SDRGP_i)}\right](T+SDRGP_i)e^{-1/2\left(\frac{T+SDRGP_i}{SDRGP_i}\right)^2}$$

$$T0 \leq T \leq \infty$$

Similarly the expression for the left half -- the heavy dotted line -- of Fig. 6 is

$$f(-T) = RGPDP + \left[\frac{MXRGP-RGPDP}{(SIRGP)}\right](-T+SIRGP)e^{-1/2\left(\frac{-T+SIRGP}{SIRGP}\right)^2}$$

$$-\infty \leq T \leq T0$$

where SIRGP, the standard deviation, is the mnemonic for the Speed

with which there has occurred the Increase in the Rate of Growth of the Population from its old value (RPGDP) to its maximum (MXRGP).

When it is recalled that f(T) and f(-T) are the instantaneous values of the net rate of population growth, the advantage of the Rayleigh distribution can be seen; for to obtain the figures for the total population of the Northeast at any instant we must integrate one or both expressions. The rate of population growth, with time, is defined as d(PT)/(PT), where PT is the Population, Total, at any instant T. The integral of d(PT)/(PT) is the natural logarithm of PT, LNPT. So, for periods before the rate of growth of the population reaches its maximum,

$$LNPT1 = \int_{-\infty}^{T1} f(-T)\,dT, \quad -\infty \leq T1 \leq T0$$

and for periods after

$$LNPT2 = \int_{-\infty}^{T0} f(-T)\,dT + \int_{T0}^{T2} f(T)\,dT, \quad T0 \leq T2 \leq \infty$$

Raising LNPT1 or LNPT2 to the base e yields the value of the total population

$$PT1_i = (PTBS)\ e^{(LNPT1_i)} \qquad (16A)^*$$

$$PT2_i = (PTBS2)\ e^{(LNPT2_i)} \qquad (16B)$$

where

PT = Population, Total, numbers of individuals,

PTBS = Population, Total, at the Beginning of the Simulation, numbers of individuals,

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*The number attached to each equation throughout the text is that identifying the same equation in the computer program reproduced in Appendix A. Since the sequence of numbers in the program is determined by the order of calculation rather than by the order of formulation, the equation numbers here follow no apparent sequence.

LNPT = Logarithm (Natural) of the Population, Total, and

e = natural logarithm.

If we wished to simulate the model under the assumption of a constant rate of growth of population (MXRGP), we could substitute for equations (16A and B) the simple expression

$$PT_i = (PTBS)\, e^{(MXRGP)(TEBS_i)} \tag{15,16}$$

where

PT = Population, Total, number of individuals,

PTBS = Population, Total, at the Beginning of the Simulation, number of individuals,

MXRGP = MaXimum Rate of Growth of the Population, a constant throughout the simulation, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

TEBS is equivalent to the variable t in the general expression, and merely records the amount of time that has been simulated. If the initial date of the simulation were 1960 and a history had been accumulated as far as 1965, TEBS would be equal to 5 years. Thus

$$TEBS_i = TEBS_{i-1} + DT \tag{1,2,3}$$

where

TEBS = Time Elapsed since the Beginning of the Simulation, years, and

DT = time interval of simulation, Delta Time, years.

The simple expression, assuming a constant rate of population growth, will be substituted in the majority of the simulation runs, including that which we designate the base case and describe in Section IX. However, when we turn in Section XI to the effects of instituting a

birth control program in the Northeast, we shall incorporate the Rayleigh distribution, reviewing its formulation in the process.

Starting with a known population for the Northeast (PTBS) as of some date -- for example, 1960 -- we shall assume that the rate of growth of the number of inhabitants of the Northeast will be equal to the rate of growth of this initial population. The particular individuals living in the Northeast at a later date may differ, some having emigrated to other regions of Thailand, others having immigrated into the Northeast; but the emigrants will be assumed to have been replaced by an equal number of immigrants of similar characteristics so that the total number is unchanged. In short, we are assuming no net migration to or from the region. There is some evidence to support this assumption: in the Census of Population of 1960, there were 186,044 individuals living in the Northeast who had not been born there.* This number was offset by the 180,476 individuals who had been born in the Northeast but who, by the time of the census, had taken up residence elsewhere.** The net migration of persons is 0.06 percent of the total in the Northeast -- not a very sizable figure.

This population will be divided more or less into two major classes -- those living in the villages and those living in the towns. The villagers derive their livelihood in the traditional manner, primarily from agriculture but also from stock raising, trading, handicrafts, teaching, and other activities that permit rural self-sufficiency. This group will be labeled PEA, the Population Employed in Agriculture. It will include all those villagers who are employed, as well as their families. Not included, however, will be those (plus their families) who happen to be living in the villages but who are without employment; they will be one portion of the unemployed.

Whereas those employed in the traditional manner will constitute only one group, those employed in the towns will be subdivided into

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*[326].

**See Table 2 in Section I.

three groups according to source of income. The first will be civil servants and their families, labeled PEG, the Population Employed by Government. Their numbers will be considered later, in the discussion of policy instruments; at present only the term is needed.

The second group in the modern sector will be made up of those who own the instruments of production, that is, the capitalists. As Thailand is primarily a country of family firms, the number of capitalists will be assumed to equal the number of firms (to be derived subsequently):

$$PØKI_i = NFI_i \tag{14}$$

where

PØKI = Population Øwning the c(K)apital invested in Industry, numbers of individuals, and

NFI = Number of Firms in Industry.

Subtracting these two groups of individuals (those employed by government and those owning the capital goods) and the third (those representing the population employed in agriculture) from the total population, we are left with the number who are available for private employment within the modern sector:

$$PAEI_i = PT_i - PEA_i - PØKI_i - PEG_i \tag{17}$$

where

PAEI = Population Available for Employment in private Industry and services, number of individuals (plus families),

PT = Population, Total number of individuals,

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals (plus families),

PØKI = Population Øwning the c(K)apital invested in private Industry, number of individuals (plus families), and

PEG = Population Employed by Government, number of individuals (plus families).

When those who are actually employed in private firms are subtracted from this residual, the remainder is the number of individuals (workers plus families) without support:

$$PU_i = PAEI_i - PEI_i \tag{41}$$

where

PU = Population Unemployed, number of individuals (plus families),

PAEI = Population Available for Employment in Industry and services, number of individuals (plus families), and

PEI = Population Employed in private Industry, number of individuals (plus families).

Some of these unemployed will be living in villages, the remainder in towns -- where is not of interest. Of interest, though, are their numbers and mobility: we shall assume that they are available for (and ready to accept) employment in either the traditional or the modern sectors; and therefore that PU can fall to zero, and will if full employment is attained. This is a strong assumption and will be discussed at greater length in the next section.

It is understandable that we have separated the unemployed (PU) from the employed, given our concern over the Northeasterner's opportunity to earn his livelihood. The separation of the rest of the constituents of the total population follows from other considerations. Those employed by the government (PEG) are separated from those employed by private entrepreneurs (PEI) because of the different locus and agent of decision. In the case of civil servants their level of employment is set by the ministers in Bangkok, on the basis of their budgets and the competing needs of other regions. In the case of private employees their level of employment is set by entrepreneurs

engaged in economic activities in the Northeast, on the basis of the demands for their goods, wage rates, and labor's contribution to output.

The entrepreneurs or capitalists (PØKI) are considered separately from their employees (PEI) for two reasons: (1) Because of possible disparities between incomes from the ownership and administration of capital (obtained by PØKI), and incomes from wages (obtained by PEI); and (2) Because of possible disparities in origin (the entrepreneurs -- among whom are many Thais from the central basin and many Chinese -- being more likely than their workers to have immigrated into the Northeast). There are, to be sure, difficulties in statistically accomplishing this separation; for example, how should one-man enterprises, or firms occupying only the members of one family be allocated? This difficulty will be dealt with in Section VIII when we consider the actual number of firms. Briefly, our solution will be to consider as entrepreneurs only those who employ persons from outside their own families.

The final group in the population -- those individuals earning their livelihood in the traditional sector (PEA) -- is separated from the groups in the modern sector because of its relative geographical, technological, and cultural isolation. Although numerically this is by far the largest group, larger even than all the rest combined, it is not subdivided. The Thai village is integral, as will be the villagers during the course of our analysis.

IV. THE MODEL: OUTPUT AND EMPLOYMENT

In the previous section we divided the population of the Northeast into two groups, agricultural and nonagricultural. Employed persons and their families are allocated to one or the other depending sometimes upon whether they earn their livelihood in farming or outside of farming and sometimes upon whether they live in a village or in a town. Since these two criteria for allocation -- occupation and location of residence -- are conceptually similar and since government statistics seldom make any distinction between the two,* we assume that they are equivalent, leading to identical estimates. Mobility between the two major groups is provided by the unemployed, who are allocated to neither. However, they are assumed to be capable of accepting any employment, were it offered at a suitable wage.

The economy of the Northeast is also divided into the traditional and the modern sectors. The traditional sector of the economy employs all the farmers and their families, the modern sector all the nonfarm workers and their families; the traditional sector provides income for all the villagers, the modern for all the town-dwellers.

The number of individuals in each sector depends upon employment opportunities. The assumption that the unemployed are mobile between occupations assures that they are mobile between sectors, since the two are congruent. This is a rather strong assumption, for it requires that location and outlook be a consequence of the type of employment gained and not vice versa. Provided there is some unemployment, each sector will grow as fast as new jobs are created within it. The rate at which labor can be shifted from one sector to another is never limiting.

Evidence of the mobility of labor from traditional to contemporary pursuits is not extensive, but what little there is** suggests that

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*See, for example, the classifications in [165], p. 11, and [330], pp. 83-86.

**See, for example, tales of the migration of young Thais from the villages of the Northeast to Bangkok in [173] and [311]; [244] and

the unemployed Thai does seek to earn a livelihood, is aware of activities outside of farming, and having secured employment, does perform adequately in his new job and adapt reasonably well to his new environment, and if opportunities arise there, will return to his native village.

Only those for whom there are no jobs available are unemployed, so our attention must shift from the residual to the established employments. Let us first consider employment and output in the traditional sector. Rather than state directly how many are employed and what their output is, we shall begin with the amount of the complementary factor of production, land.

An expression for the quantity of land currently under cultivation is

$$k_t = \frac{\nu}{1 + e^{-\lambda t}}$$

where

k = the amount of arable land under cultivation,

t = time,

e = natural logarithm, and

ν, λ = parameters.

The shape of the curve generated by this equation is shown in Fig. 7. The amount of cultivated land is negligible at the most distant point in the past, then rises first with increasing and then diminishing speed toward a ceiling (ν). The rate at which the amount of land rises is measured by the parameter λ, and the fraction of the ultimate quantity used at time zero equals $\nu/2$.

In the above equation, the ceiling (ν) is fixed, but in the expression actually used we permit it to be raised steadily. In this

[245]. An econometric study of mobility from the traditional to the modern sector in Japan ([449], particularly p. 198) corroborates these accounts.

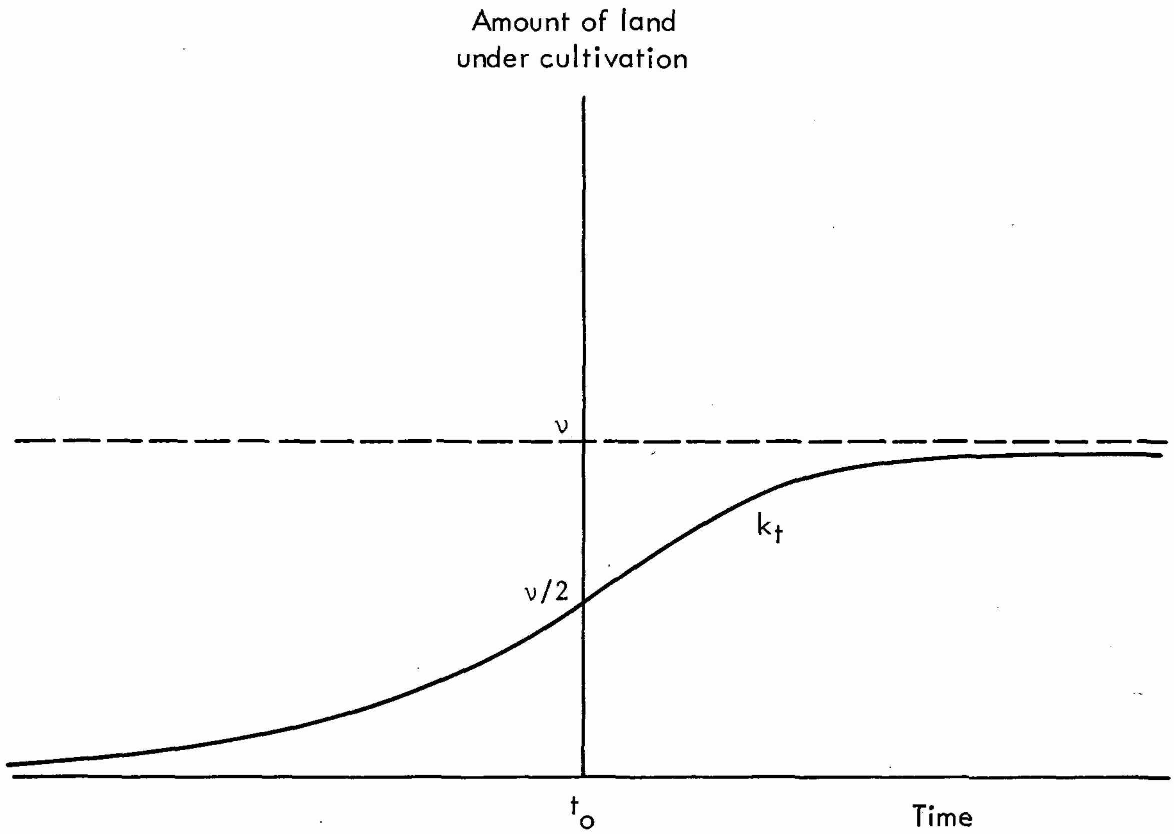

Fig.7— General trend in the amount of land under cultivation

expression, the amount of land under cultivation (k), is replaced by the symbol KUA. KUA is some fraction of all tillable land, itself composed of what is believed to be inherently arable (KLB) and what can be made arable by the government through such investments as irrigation (CIGA). KLB will not change, but CIGA is expected to increase. The amount of land cultivated approaches the ceiling (KLB + CIGA) asymptotically through time, at a rate determined by the constant (KUAC2) in the following equation:

$$KUA_i = \frac{(KLB + CIGA_i)}{1 + (KUAC1)\ e^{-(KUAC2)(TEBS_i)}} \qquad (8)^*$$

where

KUA = c(K)apital Utilized in Agricultural production, rai of land,

KLB = c(K)apital available for use in agriculture, represented by the total stock of arable Land in the Base year, rai of land,

CIGA = Cumulative Investment by Government in Agriculture, rai of land,

KUAC1,
KUAC2 = coefficients used in estimating the increase through time of the portion of the c(K)apital invested in land that is actually Utilized in Agricultural production, Constants, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

The stock of easily cultivated land in existence is fixed, but the net investment of government in agriculture is the sum of the yearly increments:

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*As mentioned in Section III, the numbers after the equations refer to the order in which they are listed in the computer program.

$$CIGA_i = CIGA_{i-1} + IGLA_I \quad (7)$$

where

CIGA = Cumulative Investment by Government in Agriculture, rai of land, and

IGLA = Investment by the Government augmenting the stock of Land in Agriculture, rai per year.

The amount by which the stock of land is augmented through investment by the government (IGLA) is assumed to be directly proportional to the expenditure in the same year

$$IGLA_i = (IGAC)\ (EGA_i) \quad (6)$$

where

IGLA = Investment by the Government augmenting the stock of Land in Agriculture, rai per year,

IGAC = coefficient used in determining the productivity of Investment by the Government in increasing the stock of land in Agriculture, a Constant, and

EGA = Expenditures by the Government in Agriculture, baht per year.

By cultivating land, the farming population is able to obtain its livelihood. The manner in which the two factors -- land and labor -- are combined to produce a homogeneous output is expressed by the "production function." To begin with, two simple and contrasting production functions are presented, the second of which we prefer. In the first it is assumed that the factors can be used in varying proportions to produce the output; in the second, that there is no possibility for substitution. Which of these two production functions is the more nearly appropriate depends upon the "technology" used by the Thais in agriculture -- "technology" meaning all the factors affecting the transformation of inputs into output.

A simple relationship, between the quantities of the factors of production and output, which permits factor substitution is*

$$q_t = \alpha e^{\mu t} (k_t)^{\beta} (p_t)^{1-\beta}$$

where

q = output, over the period that the factors of production are applied,

k = the amount of land under cultivation (the dependent variable in the equation on page 46),

α, μ and β = parameters.

This expression has two characteristics: (1) Since the sum of the two exponents (β and $1 - \beta$) equals unity, there are constant returns to scale. In other words, if the quantities of both factors of production are multiplied by a constant, output is multiplied by the same constant. (2) The output changes in a fixed proportion each time period. If it is assumed that the factors were more skillfully used each successive year, this proportion ($e^{\mu t}$) would be greater than unity.

But in Section I we argued that there is little likelihood for substitution, that the Thais of the Northeast feel that one male alone is capable of cultivating a certain number of rai, and if there is a second male in the family he would not attempt to add his labor to a holding of this size but would seek employment elsewhere. Labor is applied to land in fixed proportions; extra land is left uncultivated and extra labor is free for other employment.

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*This is the type of production function chosen by Ruttan because "It provides immediate elasticities of output with respect to the individual factors of production; it permits decreasing marginal returns to come into evidence without using too many degrees of freedom; and it has demonstrated its empirical usefulness at the firm level in [American] agricultural economics research." [448], pp. 24-32; quotation from p. 31.

In the alternative type of production function, the combination of productive factors cannot be varied. When written mathematically this yields the following expression:

$$q_t = \begin{cases} q_t^1 = e^{\mu t} (\tau k_t), & q_t^1 \le q_t^2 \\ q_t^2 = e^{\mu t} (\omega p_t), & q_t^1 > q_t^2 \end{cases}$$

where

q = output over the time period considered, as before,

k = amount of land under cultivation, as before,

p = population, as before,

t = time, as before,

μ = parameter reflecting improvements in techniques, and

τ, ω = parameters -- technical coefficients (output/land and output/labor ratios, respectively).

Which of these terms governs the above expression depends upon which is the limiting factor. If population is limiting, then output is measured by the second part; if land is limiting, output is measured by the first part. If land is limiting, extra labor contributes nothing; if labor is limiting, extra land contributes nothing.

It is the second type of production function that is used most often in the present study -- that is, it is generally assumed that the production function for agriculture in Thailand is characterized by fixed coefficients.* Output is equal to the quantity of the factor of production in limited supply multiplied by the appropriate output/factor ratio. Since agricultural labor is relatively abundant

*In Section X we do simulate the behavior of the model with variable factor proportions in agriculture, but only as a special case.

in the Northeast, the output of the traditional sector (ØAS) will be equal to the scarce factor (the area of land under cultivation) times a constant:

$$ØAS_i = (CØAS_i)\ (KUA_i) \tag{9}$$

where

ØAS = Output of the Agricultural Sector, units per year,

CØAS = Coefficient used in calculating the Output of the Agricultural Sector, units per rai per year, and

KUA = c(K)apital Utilized in Agricultural production, rai of land.

This constant (CØAS), the output/land ratio, is assumed to increase each year by a certain fraction (CØASC2) as a result of technological progress; an omnibus term including all increases in productivity that occur with the passage of time:

$$CØAS_i = (CØASC1)\ e^{(CØASC2)\ (TEBS_i)} \tag{5}$$

where

CØAS = Coefficient used in calculating the Output of the Agricultural Sector, units per rai per year,

CØASC1, 2 = Coefficients used in calculating the Output of the Agricultural Sector, Constants, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

The population that this output supports is equal to the amount of land under cultivation multiplied by the labor/land ratio in agricultural production:

$$PEA_i = (LLRA)(KUA_i) \tag{10}$$

where

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals,

LLRA = Labor/Land Ratio in Agriculture, individuals per rai, and

KUA = c(K)apital Utilized in Agricultural production, rai of land.

This completes the expressions for output and employment in the traditional sector. In summary, a single, homogeneous agricultural good is produced through the application of labor to land, in fixed proportions. Land is believed to be scarce and labor abundant, so that total output and the population it supports are both limited by the amount of land under cultivation. Not all the tillable land in the Northeast is now being farmed, although each year the amount still unexploited diminishes as cultivation is pushed toward the margin. However, government investment in agriculture does raise the total stock of tillable land, and technological progress in farming raises the productivity of each rai that is cultivated. The total population employed in agriculture can increase only as rapidly as the cultivation of land increases, and per capita output can increase only as rapidly as productivity increases. Real income for the traditional sector as a whole rises with both the increase in the total population employed and the increase in productivity.

Thus, with the exception of government intervention through agricultural investments, employment in the traditional sector is determined independently from the rest of the model. The population supported by the land is either unaware of or unaffected by events taking place outside the villages. We assume that farming is preferred to any other occupation by those who have land, no matter what the inducements of urban life.

In private enterprise in the modern sector, an equally simple governing motivation is assumed: so long as it is profitable to

expand output, output will be expanded. But this condition will only be imposed later; for the present we shall proceed to develop the production function for private enterprise in the Northeast of Thailand.

The production function for private enterprise will describe the production of individual firms, each of which combines labor and capital to produce a single, homogeneous industrial good. There is already a difference in aggregation between the production relations for industrial and agricultural goods: our production function for agriculture is a macro-relation. Single farms and farmers are unidentified; only the aggregates -- the total amount of land being cultivated and the total population cultivating this land -- are measured.

There is a second difference between the production functions, that of effect of scale of operation. Although we believe that the output of the traditional sector in the Northeast of Thailand can be adequately described by a production function with constant returns to scale, the output in the modern sector cannot; for one of the aspects of industrialization is the existence of increasing returns, both for the single industrial enterprise and for the collectivity. Therefore, to allow for the effects of the industrialization of Thailand on output and employment in private enterprise in the Northeast a theoretical scheme that exhibits economies of scale must be devised. Such a production function for the firm will be formulated first, and then expanded to include all of private enterprise.

Beginning with the single firm, let us suppose that the relation between its inputs and outputs is

$$q_t = f\ (k_t, p_t)$$

where

q = the homogenous output of the firm over a given period of time, t, derived from inputs of

k = capital, and

p = labor.

For the moment the relation between the inputs in the production function will be left imprecise in order to concentrate on the relation between inputs and output. We should like this to display increasing, and subsequently decreasing, returns to scale.

As the assumption of varying returns to scale will increase the complexity of the model to the point where we are unable to provide analytic solutions, the reason for making this assumption should be given. Basically it is that it is more realistic, that variable returns to scale are manifest in the modern sector of a dualistic economy. The following phenomena all yield economies of scale: (1) The design of large* and specialized equipment and its operation by skilled workers in numbers not limited by the size of a single family or village; (2) the harmonization of machines with different capacities and the synchronization of processes with different rhythms; (3) the economies of buying, storing, transporting, and selling in bulk; and (4) the reserve provided by workers able to share knowledge and, in an emergency, to substitute for one another. As its rate of output increases, the small firm finds it progressively easier to standardize items, to control the conditions under which these are produced and to diagnose and correct faults. But as its rate of output increases further, the no-longer small firm experiences diseconomies, associated in the short run with the increasing difficulty of extracting more output from facilities with limited capacities and in the long run with the increasing difficulty of coordinating and administering operations. Managers, lacking knowledge of distant activities, suboptimize. Decisions become inconsistent; they may even become imaginary when the channels of communications become long and the information that finally arrives is fragmentary. Ultimately diseconomies of scale outweigh economies, and technical efficiency diminishes.

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*Particularly vessels, whose capacity (≡ volume) tends to increase with size at a greater rate than total cost (≡ surface area).

One equation that exhibits first economies and then diseconomies of scale is

$$q_t = \chi e^{-\frac{\theta}{g(k_t, p_t)}}$$

where

q, k and p are the same as above, and

χ and θ = parameters.

The first and second derivatives of this function are

$$\frac{dq_t}{dg} = \theta \chi e^{-\frac{\theta}{g(k_t, p_t)}} \left(\frac{1}{g(k_t, p_t)} \right)^2$$

and

$$\frac{d^2 q_t}{dg^2} = \theta \chi e^{-\frac{\theta}{g(k_t, p_t)}} \left(\frac{\theta}{[g(k_t, p_t)]^4} - \frac{2}{[g(k_t, p_t)]^3} \right) .$$

Adding both production factors simultaneously increases output in greater than equal proportions up to an inflection point, where $g(k_t, p_t) = \theta/2$. Beyond this point, adding still more inputs always increases output, but in less than equal proportions. But no matter what the initial rate of output, adding more inputs always yields an increase in output; returns to scale diminish only in a relative sense.

In the production function described by the equation above, there are two parameters, χ and θ. By taking logarithms of both sides,

$$\ell n \; q_t = \ell n \; \chi - \frac{\theta}{g(k_t, p_t)}$$

we can see that as $g(k_t, p_t)$ becomes infinite, q_t approaches the ceiling χ; hence, maximum output depends solely on the first

parameter.* From the expression for the second derivative, we see that the value at which economies of scale are exhausted (that is, where $d^2qt/dg^2 = 0$) depends solely on the second parameter, θ.

Curves of q_t for varying values of χ, of θ, and of both are drawn in Figs. 8a, 8b, and 8c, respectively; in all three the inflection points are enclosed within a small square. When θ is constant (Fig. 8a), the inflection points are stacked one above another; the locus of all possible inflection points would be a vertical line at $g(k_t,p_t) = 1/2$ (and, in general, $\theta/2$). If we were to identify all the points where $q_t/g(k_t,p_t)$ was at a maximum (that is, where the productivity of the inputs was the highest, and, assuming constant factor prices, where average cost was lowest), these too would be stacked, on the line $g(k_t,p_t) = 1$ (and, in general, $= \theta$). Minimum costs are obtained at the fraction of maximum attainable output equal to θ/χ.

If the consequence of technological progress were to reduce the amount of inputs needed to produce any given output, while leaving constant the quantity of inputs at which their productivity was the highest (and, assuming constant factor prices, where average costs were lowest), then the phenomenon could be accounted for wholly within the coefficient (χ) preceding the exponential term in the equation. The production function for the firm, whose techniques were improving as time passed, could be

$$q_t = \delta e^{\eta t - \frac{\theta}{g(k_t,p_t)}} .$$

where χ now equals $\delta e^{\eta t}$.

---

*Another form of the production function, used by Ranis and Fei ([413], p. 546), that also yields variable returns to scale is

$$q_t = [h(k_t,p_t)] - \alpha[h(k_t,p_t)]^2.$$

Beyond a certain rate of output ($h' = 1/2\alpha$) this equation displays

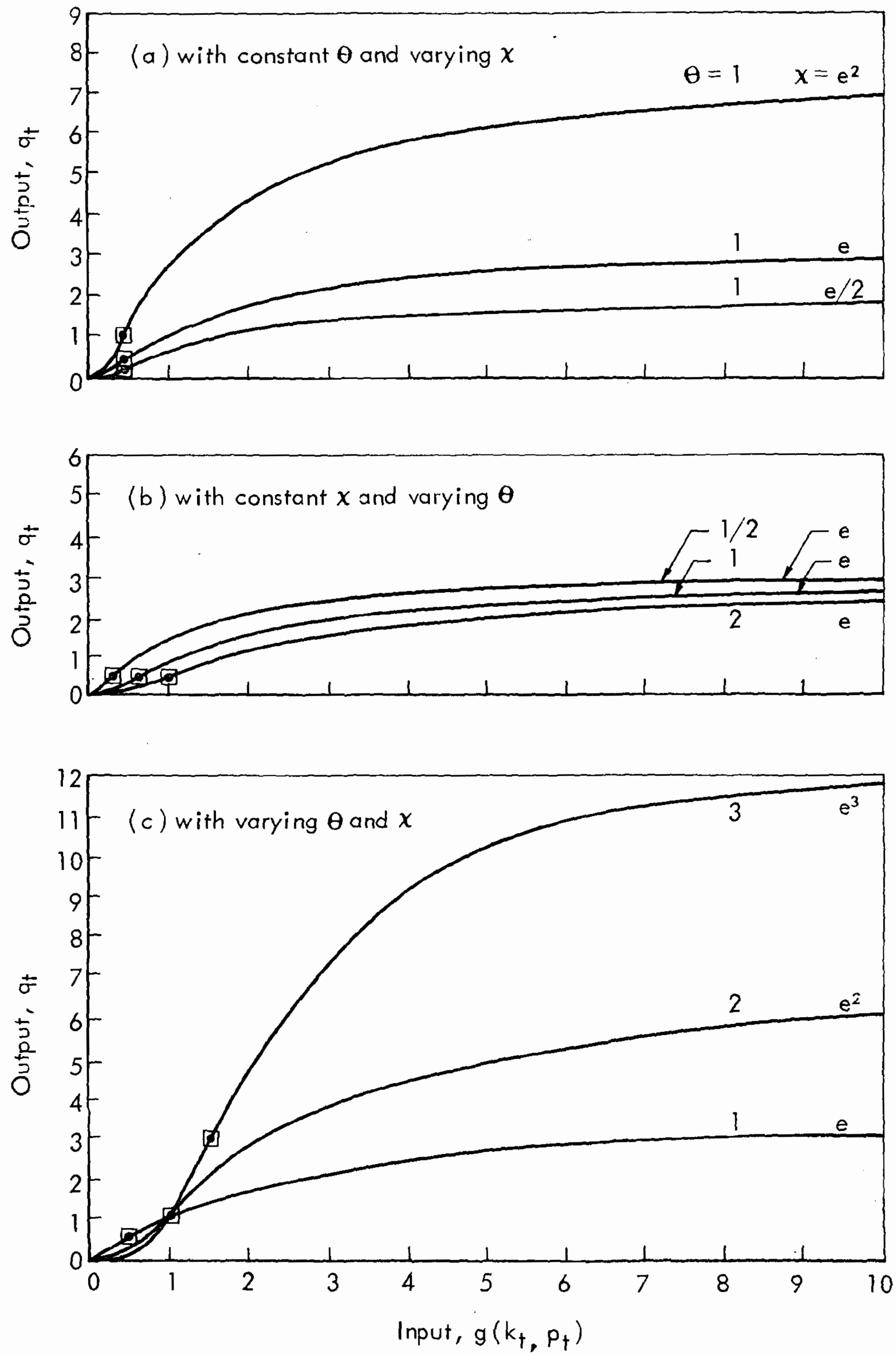

Fig.8 — Plot of the production function $q_t = \chi e^{-\frac{\theta}{g(k_t,\, p_t)}}$

But if the consequence of technological progress were to increase still further the output at which the productivity of the inputs was the highest (so that not only the quantity of output but also the quantity of inputs with which this output were produced was to increase through time), the coefficient in the exponential term of the equation would also have to be *a function of time*. If such were the case, Fig. 8c, not Fig. 8a, would more accurately portray the changing relationship between inputs and outputs.

Such a production function would be

$$q_t = \delta e^{\eta t - \frac{\theta}{g(k_t, p_t, t)}} .$$

To simplify this somewhat we can make the common assumption that technological progress is "neutral" in the sense that, for a given ratio of the one factor of production (k) to the other *factor* of production (p), the ratio of their marginal products is the same after the introduction of the new technique as it was before. This permits us to rewrite the above equation as

$$q_t = \delta e^{\eta t - \frac{\theta(t)}{f(k_t, p_t)}} .$$

Assuming that the change, through time, in the second term of the exponent of this equation is as regular as that of the first term, we can simplify the expression still further:

---

absolutely diminishing returns to scale, a consequence that led the authors to replace it at this point by a second equation, $q_t = M$, where M is a constant equal to the maximum output attained, the same as our χ. We have used our continuous form rather than their discontinuous one.

$$q_t = \delta e^{(\eta - \frac{\xi}{f(k_t, p_t)})t}$$

where ξ equals $\theta(t)$ and, like η, would be expected to be positive. This is the form of the production function that we shall use. It exhibits first increasing and then decreasing returns to scale, and encompasses technological progress, both as increases in output from existing inputs and also as extensions in the range of economies of scale.

Next we need an expression for the private portion of the modern sector, composed of all firms. The production function for the sector as a whole is stated as

$$Q_t = N_t q_t = N_t \delta e^{(\eta - \frac{\xi}{f(k_t, p_t)})t}$$

where

Q_t = output of the sector over the time period considered,

N_t = number of firms in existence,

k_t, p_t = quantities of the inputs of the firm, and

δ, η, ξ = parameters.

Under a regimen of perfect competition N_t would be a dependent variable, determined jointly by the demand for the sector's products and by the value of q_t at which minimum average costs were obtained. N_t would decrease, increase, or remain constant as total demand increased less rapidly, more rapidly, or with the same speed as the expansion of minimum-cost output with technological progress. However, perfect competition does not reign in Thailand any more than

in any other country; consequently, the number of firms will not adjust automatically to market forces. We argue, rather, that the number of firms in existence will be one of the instruments of government policy, varying as the rulers of Thailand choose to vary their educational, credit, trade, taxation, and subsidy programs, their treatment of foreigners and of their own different ethnic groups, and their granting of private and public monopolies. By its influence over the number of firms in existence, the Thai government does in actuality (and in our model will, through the operation of the equation above) affect the level of output and the efficiency with which resources are used.

We now have the means to write the equation(s) for the output of private enterprise. The form is the same as the last equation above, but the expression is longer because of the substitution of multiple capital Latin letters for single, lower-case Greek ones. To make it more manageable, we let ØFI equal the term $f[k_t, p_t]$; and to obtain initial values for output we insert two parameters (CØIC2 and CØFC4), both equal to unity. CØIC3 reflects the increases in the maximum output obtainable from the unlimited use of inputs, and CØIC5 reflects the extension in the range over which economies of scale can be realized. The first part of the equation is

$$\text{ØIS}_i = (\text{NFI}_i)(\text{CØIC1})e^{\text{CØIC2}+(\text{CØIC3})(\text{TEBS}_i) - \frac{\text{CØIC4}+(\text{CØIC5})(\text{TEBS}_i)}{\text{ØFI}_i}}$$

where

ØIS = Øutput of the Industrial Sector, units per year,

NFI = Number of Firms in the Industrial sector,

CØIC1,2,3,4,5 = Coefficients used in the calculation of the Øutput of the Industrial sector, Constants, various dimensions,

TEBS = Time Elapsed since the Beginning of the Simulation, years, and

ØFI = Øutput Function for private Industry, dimensionless.

As was mentioned in the derivation of the general form of the equation, the exponential term and the constant which immediately precedes it (CØIC1) constitute the production function for the firm. This is then multiplied by the number of firms in the industrial sector (NFI) to obtain the total industrial output. The inflection point is found where $ØFI_i$ equals one-half CØIC4 + (CØIC5)($TEBS_i$), and minimum average costs are obtained when $ØFI_i$ equals CØIC4 + (CØIC5)($TEBS_i$).

The term (ØFI) in the exponent of the equation reflects the way in which the two production factors, capital equipment and labor, are combined. Because it is simple and because we have no evidence to the contrary, we shall assume that the combination takes the form of a homogeneous Cobb-Douglas function, and we shall select values for the two coefficients (ØFIC1 and ØFIC2) which will make it linear:

$$ØFI_i = \left(\frac{KI_i}{NFI_i}\right)^{ØFIC1} \left(\frac{PEI_i}{NFI_i}\right)^{ØFIC2} \left(\frac{1}{ØFIC3}\right)$$

where

ØFI = Øutput Function for private Industry, dimensionless,

KI = total stock of c(K)apital in private Industry, baht,

NFI = Number of Firms in private Industry,

ØFIC1,2,3 = coefficients used in the Øutput Function for private Industry, Constants, various dimensions, and

PEI = Population Employed in private Industry, number of individuals.

Although these two equations define the production function for private enterprise, neither is computed in exactly the above form. Before the computation can be described, the supply function for labor must be developed, as the amount of labor which will actually be employed by the firms will be determined jointly by their demand and by the willingness of industrial workers to supply their skills. In developing the supply schedule of labor a new variable, FAEI, is introduced. FAEI represents that fraction of all those available for employment in private enterprise who obtain employment. It is determined by dividing actual employment by potential employment, both these variables having already been defined in the previous section.

$$FAEI_i = \frac{PEI_i}{PAEI_i} \tag{33}$$

where

FAEI = the Fraction of those Available for Employment in private Industry actually employed, dimensionless,

PEI = Population Employed in private Industry, number of individuals, and

PAEI = Population Available for Employment in private Industry, number of individuals.

When FAEI equals unity, all of those available for employment have obtained jobs; when it equals zero, the total potential labor force is wholly unemployed.

As FAEI increases, we should expect the average wage to rise, reflecting the increasing difficulty of drawing still more of the potentially available labor into employment. The actual relationship is expressed as:

$$FAEI_i = 1 - \left[\frac{WDFC}{(WEI_i/WEA_i)-1}\right]$$

where

FAEI = the Fraction of those Available for Employment in private Industry actually employed, dimensionless,

WDFC = Wage DiFferential between wages in industry and in agriculture necessary to mobilize the unemployed, dimensionless, a Constant,

WEI = annual Wage of those Employed in private Industry, baht per person per year, and

WEA = annual Wage of the population Employed in Agriculture, baht per person per year.

WDFC is equal to the minimum differential between the rural and urban wage necessary to overcome the friction of movement between the two locations. For example, if the average yearly wage in agriculture (WEA) were equal to 1,000 baht a year, WDFC might be equal to 1/10 of that, or 100 baht per year; this would signify that a wage in industry of at least 1,100 baht is necessary to mobilize labor. If the employment rate were 50 percent, the going wage in industry, according to the equation above, would be equal to 1,200 baht per year. If unemployment were reduced to 10 percent (that is, if FAEI were equal to 0.9), the wage in industry would be 2,000 baht per year. With unemployment reduced again by half (that is, FAEI equal to 0.95) the industrial wage would rise to three times that in agriculture; at 2 percent unemployment, to six times that in agriculture.

This supply schedule for industrial labor is illustrated in Fig. 9, where schedules for two different values of the wage differential (equal to 1/10 and 1/5 the average wage in agriculture) are drawn. The higher the wage differential, the higher the supply schedule throughout and the more rapidly it rises as full employment is approached. Given the form of the supply function, we need only one observation to determine the value of WDFC; we obtain it from

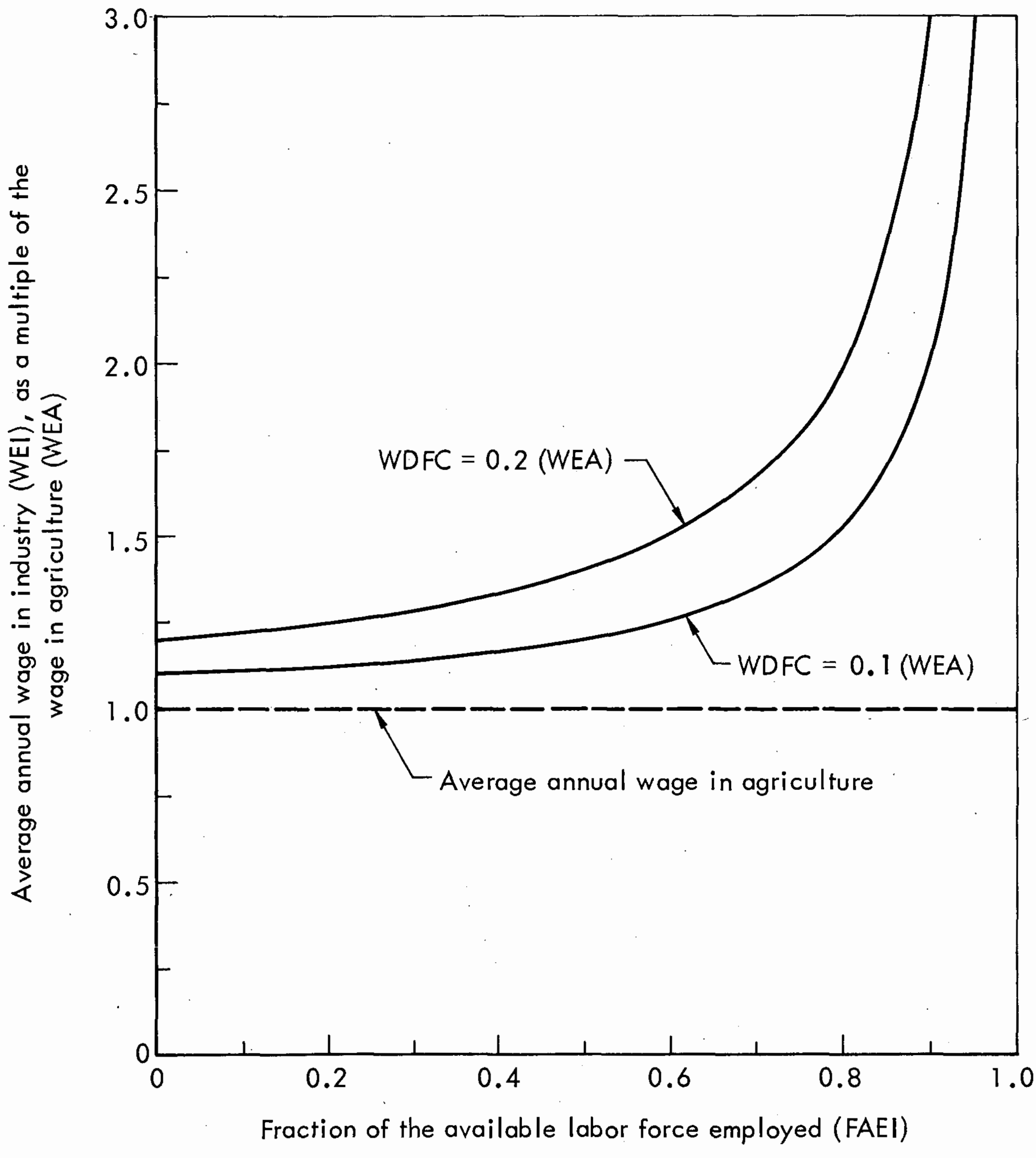

Fig. 9 — The supply schedule of labor in industry

estimates of agricultural and industrial wage rates and of the fraction employed, in some recent year.

With a labor supply schedule and a production function we can now proceed to determine employment, wages, and prices in private enterprise. In brief, given certain data, entrepreneurs will first set their rate of output. Next, they adjust their labor force to the desired level of operation. These adjustments by all firms to new levels of operation will produce a change in the wage rate. Entrepreneurs will then calculate the effects of these adjustments on the productivity of the marginal worker; the output of the marginal worker will be compared with his wage to determine his contribution to the firm's total revenue. Finally, the price of the product will change to reflect the changes in production cost.

The data on which entrepreneurs of the Northeast base their first decision are the level of demand for their product throughout the region as a whole and the portion of that demand that is satisfied by local production. For the entrepreneurs themselves these two pieces of information are assumed to be given, although for us they are variables, to be determined elsewhere in the model. Their level of output, ØIS, is simply

$$\text{ØIS}_i = (\text{FIØN}_i)(\text{TCIAV}_i) \tag{30}$$

where

ØIS = Output of the private Industrial Sector, units per year,

FIØN = Fraction of Industrial Output consumed which is produced in the Northeast, dimensionless, and

TCIAV = Total Consumption of Industrial output, AVeraged, units per year.

Equation (30) implies that entrepreneurs, collectively, set their production rate equal to a fraction of the rate at which their product is being consumed -- they tend to supply a portion of what has been demanded. There is

as yet no consideration of their costs of production, nor of their profits, as there would be if, in the model, decisions were made simultaneously. But simulation as a technique requires that decisions be made in sequence, using data accumulated from previous events.

The second decision the entrepreneurs make is how much labor to employ. Labor being the only variable factor of production, they merely calculate how much they need in order to produce the desired output within the existing plant under the current technology. The expression(s) for the production function will provide the answer, when they are rewritten so that the amount of labor (PEI) becomes the dependent variable and the rate of output (ØIS) an independent variable. Two other independent variables -- the number of firms in existence and the total investment in plant (having been determined elsewhere in the model) -- are considered to be given to the entrepreneurs at the time of the employment decision.

The calculation of the desired level of employment proceeds as did the formulation of the production function, with reversal of various independent and dependent variables. First ØFI is calculated from ØIS, using the first part of the production function:

$$\text{ØFI}_i = \frac{\text{CØIC4}+(\text{CØIC5})(\text{TEBS}_i)}{-\ln(\text{ØIS}_i)+\ln(\text{NFI}_i)+\ln(\text{CØIC1})+\text{CØIC2}+\text{CØIC3}(\text{TEBS}_i)} \qquad (31)$$

where

ØFI = Øutput Function for private Industry, dimensionless,

TEBS = Time Elapsed since the Beginning of the Simulation, years,

ØIS = Øutput of the Industrial Sector, units per year,

NFI = Number of Firms in the Industrial Sector, and

CØIC1,2,3,4 and 5 = Coefficients used in the calculation of the Øutput in the Industrial sector, Constants, various dimensions.

and then the level of employment:

$$PEI_i = NFI_i \left(\frac{(\emptyset IC3)(\emptyset FI_i)}{\left(\frac{KI_i}{NFI_i}\right)^{\emptyset FIC1}} \right)^{\frac{1}{\emptyset FIC2}} \tag{32}$$

where

PEI = Population privately Employed in Industry, number of individuals,

NFI = Number of Firms in private Industry,

ØFI = Øutput Function for private Industry, dimensionless,

KI = total stock of c(K)apital in private Industry, baht, and

ØFIC1,2 and 3 = coefficients used in the Øutput Function for private Industry, Constants, various dimensions.

Once entrepreneurs have decided how many workers to employ, labor is forthcoming, at a wage determined according to laborers' willingness to supply their services. The labor supply schedule has already been formulated in terms of the fraction of the labor force actually employed. Knowing the number in the labor force (PAEI), and having just calculated the number employed (PEI), we can readily calculate the number employed according to Eq. (33). Together with an estimate of the wage in agriculture, we can then calculate the wage rate for the employees of private industry by rearranging the terms of the labor supply function:

$$WEI_i = WEA_i \left[1 + \frac{WDFC}{1-FAEI_i}\right] \tag{34}$$

where

WEI = annual Wage of those Employed in private Industry, baht per person per year,

WEA = annual Wage of those Employed in Agriculture, baht per person per year,

WDFC = Wage DiFferential between wages in industry and in agriculture necessary to mobilize the unemployed, dimensionless, a Constant, and

FAEI = the Fraction of those Available for Employment in private Industry actually employed, dimensionless.

From the third step in the sequence we pass on to the fourth, the calculation of the contribution to output of the marginal worker. Mathematically this is $d(\emptyset IS_i)/d(PEI_i)$, or the derivative of the output of private industry with respect to the quantity of labor employed. The derivative is taken after combining the two parts of the production function, Eqs. (31) and (32), and is assigned the letters MPPL:

$$MPPL_i = \left(\frac{\emptyset IS_i}{PEI_i}\right) (\emptyset FIC2) \left[\frac{C\emptyset IC4+C\emptyset IC5(TEBS_i)}{\emptyset FI_i}\right] \tag{35}$$

where

MPPL = Marginal Physical Product of Labor, units of product per man-year,

ØIS = Øutput of the Industrial Sector, units per year,

PEI = Population Employed in private Industry, number of individuals,

ØFIC2 = coefficients used in the Øutput Function for the private Industrial sector, Constant, dimensionless,

CØICA, 5 = Coefficients used in the calculation of the Øutput in the Industrial sector, Constants, dimensionless,

TEBS = Time Elapsed since the Beginning of the Simulation, years, and

ØFI = Øutput Function for private Industry, dimensionless.

The fifth step is the calculation of the addition to total revenue obtained with the output of the marginal worker. His contribution to output and the average wage have been previously calculated. But rather than use the current wage, we assume that the entrepreneur uses the average of the wages he has paid in the recent past. He weights the most

recent wage the heaviest, the next most recent the next heaviest, and so on. The value (WEIAV) used is calculated in the following equation:

$$WEIAV_i = (WEIAV_{i-1})(WEIC1) + (WEI_i)(WEIC2) \qquad (34)$$

where

WEIAV = annual Wage of those Employed in private Industry, AVeraged, baht per person per year,

WEI = annual Wage of those Employed in private Industry, baht per person per year, and

WEIC1,2 = coefficients used in determining the average annual Wage of those Employed in private Industry, Constants, dimensionless.

Assuming that their aim is to maximize profits, entrepreneurs will expand production until the wage that they must pay to an additional worker is equal to the value of that worker's output. This value is equal to the worker's additional physical output multiplied by the additional revenue that his output yields:

$$WEIAV_i = (MRI\emptyset_i)(MPPL_i)$$

where

WEIAV = annual Wage of those Employed in Industry, AVeraged, baht per person per year,

MRIØ = Marginal Revenue of Industrial Øutput, baht per unit, and

MPPL = Marginal Physical Product of Labor, units of product per man-year.

Since the variable to be solved for in the fifth step is MRIØ rather than WEIAV, the equation must be rewritten

$$MRI\emptyset_i = \frac{WEIAV_i}{MPPL_i} \qquad (36)$$

where the terms are defined exactly as before.

The sixth and final step in the sequence of calculations is the setting of the price of private industrial output. We assume that changes in the cost of production, following upon changes in the number of workers employed and in their average wage rate, will be matched by identical changes in the price of the product. Thus

$$DPI\emptyset_i = MRI\emptyset_i \tag{37}$$

where

DPIØ = Domestic Price of Industrial Øutput, baht per unit, and

MRIØ = Marginal Revenue of Industrial Øutput, baht per unit.

To the extent that competition is absent, DPIØ exceeds MRIØ, but this is one phenomenon that we cannot judge and so are forced to omit.

In this sequence of steps we have calculated the output of private enterprise, employment, the wage rate, and the price of the product. Several assumptions were necessary to permit the calculations: assumptions as to the nature of production, the motivation of entrepreneurs, the state of the labor and product markets, and, implicitly, the speed of adjustment.* And even after a sequence of six steps the cycle is not complete, for there remain still to be calculated the demand for the product, as well as several other variables taken as given by the entrepreneurs in their output, employment, and pricing decisions. These matters will be dealt with in the next section.

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*With two exceptions, we generally assumed that the adjustment was made within the period of one cycle. The exceptions were in the calculations leading up to the determination of the wage rate and the product price, for both of which the adjustment is delayed.

V. THE MODEL: INCOMES AND EXPENDITURES

In the previous section we derived expressions for the calculation of output and employment in the traditional sector and in the private, as opposed to the public, portion of the modern sector. Several variables appearing in these expressions were undetermined, most importantly those relating to the incomes and expenditures of the different population groups. This section will deal with their formation.

Income is received in payment for having produced goods and is expended in order to purchase goods. In any society, and in our model, there is a rough balance between incomes and expenditures, between output and consumption. Prices and wages act as the balancing weights, tending to equate the supply of inputs or of outputs with their demands.

In this section we will consider incomes and their expenditures. The groups enumerated in Section III will appear in turn: first, the population employed in the traditional sector; second, those employed in private firms in the modern sector; third, private entrepreneurs; fourth, government employees, and fifth, the unemployed.

The payments to those employed in the agricultural sector are determined simply. By multiplying the output of the agricultural sector by an average price of agricultural goods, the value of agricultural output is obtained.

$$VA\emptyset_i = (\emptyset AS_i)(DPA\emptyset_i) \qquad (26)$$

where

VAØ = <u>V</u>alue of <u>A</u>gricultural <u>Ø</u>utput, baht per year,

ØAS = <u>Ø</u>utput of the <u>A</u>gricultural <u>S</u>ector, units per year, and

DPAØ = <u>D</u>omestic <u>P</u>rice of <u>A</u>gricultural <u>Ø</u>utput, baht per unit.

We assume that all of this income is received by the population employed in agriculture. Some of the value of the agricultural output

could be considered as wages, the rest as return on the capital invested in the land, which in the Northeast of Thailand belongs almost entirely to individual farmers. In assuming that all rent from land accrues to the population employed in agriculture, we presume that the farmers are able to appropriate the income from government investment in agriculture. In other words, the funds are expended by the government, but the benefits accrue wholly to the agricultural population. The value of agricultural output and the income of the agricultural population can be equated thus:

$$YPEA_i = VA\emptyset_i \tag{27}$$

where

YPEA = annual earned i(Y)ncome of the Population Employed in Agriculture, baht per year, and

VAØ = Value of Agricultural Øutput, baht per year.

The average annual wage of the population in the traditional sector (workers plus their dependents) is therefore equal to the total income of the sector divided by the number of individuals.

$$WEA_i = \frac{YPEA_i}{PEA_i} \tag{28}$$

where

WEA = average annual Wage of the population Employed in Agriculture, baht per year,

YPEA = annual earned i(Y)ncome of the Population Employed in Agriculture, baht per year, and

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals.

All the income is appropriated by those who are "employed," here meaning those who are engaged in cultivating the land. The unemployed (PU) receive none of this income, even though they may be

living in the villages. We make allowance for the income which they do receive, but think of it as a transfer payment rather than as earnings from agriculture.

The income of the population employed in private business consists of wages, which were derived in the previous section:

$$YPEI_i = (PEI_i)(WEIAV_i) \tag{46}$$

where

YPEI = annual earned i(Y)ncome of the Population Employed in private Industry, baht per year,

WEIAV = annual Wage of those Employed in private Industry, AVeraged, baht per person per year, and

PEI = Population Employed in private Industry, number of individuals.

The income of private entrepreneurs is whatever is left over from the revenues received from the sale of industrial goods, after the wages of the workers have been paid:

$$YKI_i = VI\emptyset_i - YPEI_i \tag{51}$$

where

YKI = i(Y)ncome of those owning the c(K)apital in Industry, baht per year,

VIØ = Value of the Industrial Øutput, baht per year, and

YPEI = annual earned i(Y)ncome of the Population Employed in private Industry, baht per year.

The value of the Northeast's industrial output is the product of the physical volume of output and the price at which the output is ultimately sold (both determined in the previous section):

$$VI\emptyset_i = (\emptyset IS_i)(DPI\emptyset_i) \tag{38}$$

where

VIØ = Value of Industrial Øutput, baht per year,

ØIS = Øutput of the private Industrial Sector, units per year, and

DPIØ = Domestic Price of Industrial Øutput, baht per unit.

The Thai government has control over the number of civil servants it employs and the wage that it pays them, so both employment and income in government are instruments of policy. They will be considered in Section VII; at present we merely calculate the amount of the earned income:

$$YPEG_i = (WEG_i)(PEG_i) \tag{40}$$

where

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year,

WEG = average yearly Wage paid to each individual in the Employ of the Government, baht per year per individual, and

PEG = Population Employed by Government, number of individuals.

The final group, the unemployed, earns no income although it does receive some support.

If the expenditures of each group were equal to its income, we could use the terms YPEA, YPEI, YKI and YPEG, calculated above, in the demand equations. But there will be additions to and subtractions from incomes (on account of taxes and transfers) before the amounts to be spent on goods are determined. These additions and subtractions vary in their magnitude among the groups, being least significant for the wealthiest and most significant for the unemployed, who subsist entirely upon gifts. We postpone consideration of this subject until the next section, and assume for the moment that we

already have measures of each group's disposable, as distinguished from earned, income.

The disposable incomes of the various factors of production are expended on the goods that these factors produce. As in our model there are only two types of goods (agricultural and industrial) and five different population groups (listed above), we must develop expressions for the amount of each product which each group consumes. First we estimate the demand of each individual in each group. For this we need to calculate the per capita expenditures of each individual in each group. For example, the per capita expenditures of the population employed in the agricultural sector is equal to the disposable income of the agricultural population divided by the number of individuals in it.

$$PCPEA_i = \frac{DYPEA_i}{PEA_i} \tag{58}$$

where

PCPEA = Per capita Consumption of the Population Employed in Agriculture, baht per individual per year,

DYPEA = Disposable i(Y)ncome of the Population Employed in Agriculture, baht per year, and

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals.

And for the individuals in the other groups:

$$PCPEG_i = \frac{DYPEG_i}{PEG_i} \tag{61}$$

where

PCPEG = Per capita Consumption of the Population Employed by Government, baht per individual per year,

DYPEG = Disposable i(Y)ncome of the Population Employed by Government, baht per year, and

PEG = Population Employed by Government, number of individuals.

$$PCPEI_i = \frac{DYPEI_i}{PEI_i} \tag{67}$$

where

PCPEI = Per capita Consumption of the Population Employed in Industry, baht per individual per year,

DYPEI = Disposable i(Y)ncome of the Population Employed in private Industry, baht per year, and

PEI = Population Employed in private Industry, number of individuals.

$$PCPKI_i = \frac{DYPKI_i}{P\emptyset KI_i} \tag{64}$$

where

PCPKI = Per capita Consumption of the Population owning the c(K)apital goods employed in Industry, baht per person per year,

DYPKI = Disposable i(Y)ncome of the Population owning the c(K)apital goods in Industry, baht per year, and

PØKI = Population Øwning the c(K)apital invested in Industry, number of individuals.

$$PCPU_i = \frac{DYPU_i}{PU_i} \tag{70}$$

where

PCPU = Per capita Consumption of those individuals in the Population who are Unemployed, baht per year,

DYPU = Disposable i(Y)ncome of that portion of the Population Unemployed, baht per year, and

PU = Population Unemployed, number of individuals.

Expenditures are divided between agricultural and industrial goods. We formulate separate demand equations for each product for individuals in each group. The intensity depends upon the level of per capita disposable income, upon the price of the good purchased, and upon the price of the other, competing good. The three independent variables -- the price of the one good, the price of the other good, and disposable income -- will be combined multiplicatively; and the relative importance of each independent variable in determining per capita demand will be determined by its exponent (for example, by PEAAC, CEAAC, and YEAAC in Eq. (59)). The five equations expressing the demand for agricultural goods of individuals in the five population groups are expressed as follows:

$$PCAA_i = (DPA\emptyset_i)^{PEAAC} (DPI\emptyset_i)^{CEAAC} (PCPEA_i)^{YEAAC} (PCAAC) \qquad (59)$$

where

PCAA = Per capita Consumption of Agricultural goods by the population employed in Agriculture, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

PEAAC = Price Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

CEAAC = Cross-Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant,

PCPEA = Per capita Consumption of the Population Employed in Agriculture, baht per individual per year,

YEAAC = i(Y)ncome Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant, and

PCAAC = coefficient used in calculation of PCAA, a Constant.

$$PCAG_i = (DPA\emptyset_i)^{PEAGC} (DPI\emptyset_i)^{CEAGC} (PCPEG_i)^{YEAGC} (PCAGC) \qquad (62)$$

where

PCAG = Per capita Consumption of Agricultural goods by Government employees, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

PEAGC = Price Elasticity of demand for Agricultural goods by Government employees, a Constant,

DPIØ = Domestic Price of the Industrial Øutput, baht per unit,

CEAGC = Cross-Elasticity of demand for Agricultural goods by Government employees, a Constant

PCPEG = Per capita Consumption of the Population Employed by Government, baht per individual per year,

YEAGC = i(Y)ncome Elasticity of demand for Agricultural goods by Government employees, a Constant,

PCAGC = coefficient used in calculation of PCAG, a Constant.

$$PCAK_i = (DPA\emptyset_i)^{PEAKC} (DPI\emptyset_i)^{CEAKC} (PCPKI_i)^{YEAKC} (PCAKC) \qquad (65)$$

where

PCAK = Per capita Consumption of Agricultural goods by c(K)apitalists, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

PEAKC = Price Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

CEAKC = Cross-Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant,

PCPKI = Per capita Consumption of the Population owning the c(K)apital goods employed in Industry, baht per person per year,

YEAKC = i(Y)ncome Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant, and

PCAKC = coefficient used in calculation of PCAK, a Constant.

$$PCAI_i = (DPA\emptyset_i)^{PEAIC} (DPI\emptyset_i)^{CEAIC} (PCPEI_i)^{YEAIC} (PCAIC) \qquad (68)$$

where

PCAI = Per capita Consumption of Agricultural goods by Industrial employees, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

PEAIC = Price Elasticity of demand for Agricultural goods by Industrial employees, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

CEAIC = Cross-Elasticity of demand for Agricultural goods by Industrial employees, a Constant,

PCPEI = Per capita Consumption by the Population Employed in Industry, baht per individual per year,

YEAIC = i(Y)ncome Elasticity of demand for Agricultural goods by Industrial employees, a Constant, and

PCAIC = coefficient used in calculation of PCAI, a Constant.

$$PCAU_i = (DPA\emptyset_i)^{PEAUC}\ (DPI\emptyset_i)^{CEAUC}\ (PCPU_i)^{YEAUC}\ (PCAUC) \qquad (71)$$

where

PCAU = Per capita Consumption of Agricultural goods by the Unemployed, units per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

PEAUC = Price Elasticity of demand for Agricultural goods by the Unemployed, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

CEAUC = Cross-Elasticity of demand for Agricultural goods by the Unemployed, a Constant,

PCPU = Per capita Consumption of those individuals in the Population who are Unemployed, baht per year,

YEAUC = i(Y)ncome Elasticity of demand for Agricultural goods by the Unemployed, a Constant, and

PCAUC = coefficient used in calculating PCAU, a Constant.

Similarly, each group in the population consumes industrial goods, the amounts depending upon per capita disposable income and the prices of both industrial goods and the competing agricultural goods. Again the variables are combined multiplicatively and their exponents are measures of the various elasticities.

$$PCIA_i = (DPA\emptyset_i)^{CEIAC}\ (DPI\emptyset_i)^{PEIAC}\ (PCPEA_i)^{YEIAC}\ (PCIAC) \qquad (60)$$

where

PCIA = Per capita Consumption of Industrial goods by the population employed in Agriculture, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

CEIAC = Cross-Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

PEIAC = Price Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant,

PCPEA = Per capita Consumption of the Population Employed in Agriculture, baht per individual per year,

YEIAC = i(Y)ncome Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant, and

PCIAC = coefficient used in calculation of PCIA, a Constant.

$$PCIG_i = (DPA\emptyset)^{CEIGC} (DPI\emptyset_i)^{PEIGC} (PCPEG_i)^{YEIGC} (PCIGC) \quad (63)$$

where

PCIG = Per capita Consumption of Industrial goods by Government employees, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

CEIGC = Cross-Elasticity of demand for Industrial goods by Government employees, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

PEIGC = Price Elasticity of demand for Industrial goods by Government employees, a Constant,

PCPEG = Per capita Consumption of the Population Employed by Government, baht per individual per year,

YEIGC = i(Y)ncome Elasticity of demand for Industrial goods by Government employees, a Constant, and

PCIGC = coefficient used in calculation of PCIG, a Constant.

$$PCIK_i = (DPA\emptyset_i)^{CEIKC} (DPI\emptyset_i)^{PEIKC} (PCPKI_i)^{YEIKC} (PCIKC) \quad (66)$$

where

PCIK = Per capita Consumption of Industrial goods by c(K)apitalists, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

CEIKC = Cross-Elasticity of demand for Industrial goods by c(K)apitalists, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

PEIKC = Price Elasticity of demand for Industrial goods by c(K)apitalists, a Constant,

PCPKI = Per capita Consumption of the Population owning the c(K)apital goods employed in Industry, baht per person per year,

YEIKC = i(Y)ncome Elasticity of demand for Industrial goods by c(K)apitalists, a Constant, and

PCIKC = coefficient used in calculation of PCIK, a Constant.

$$PCII_i = (DPA\emptyset_i)^{CEIIC} (DPI\emptyset_i)^{PEIIC} (PCPEI_i)^{YEIIC} (PCIIC_i) \quad (69)$$

where

PCII = Per capita Consumption of Industrial goods by Industrial employees, units per individual per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

CEIIC = Cross-Elasticity of demand for Industrial goods by Industrial employees, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

PEIIC = Price Elasticity of demand for Industrial goods by Industrial employees, a Constant,

PCPEI = Per capita Consumption of the Population Employed in Industry, baht per individual per year,

YEIIC = i(Y)ncome Elasticity of demand for Industrial goods by Industrial employees, a Constant, and

PCIIC = coefficient used in calculation of PCII, a Constant.

$$PCIU_i = (DPA\emptyset_i)^{CEIUC} (DPI\emptyset_i)^{PEIUC} (PCPU_i)^{YEIUC} (PCIUC) \qquad (72)$$

where

PCIU = Per capita Consumption of Industrial goods by the Unemployed, units per year,

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

CEIUC = Cross-Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

PEIUC = Price Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant,

PCPU = Per capita Consumption of those individuals in the Population who are Unemployed, baht per year,

YEIUC = i(Y)ncome Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant, and

PCIUC = coefficient used in determining PCIU, a Constant.

All told, there are ten demand equations, each with three exponents -- one measuring the price elasticity of the good being purchased, the second the cross-elasticity of the other, competing good, and the third the elasticity of income. There is one condition placed on the values of the elasticities: namely, that there be no "money illusion." In other words, if all prices and incomes were to change in the same proportions, leaving the relative prices and incomes unchanged, demands would not be altered. For example, if the price of both agricultural and industrial goods doubles, and disposable incomes double along with them, the same quantities of each of the two goods would still be purchased. For the demand

equations to display this characteristic of homogeneity, the sum of the three exponents (for example, PEAAC plus CEAAC plus YEAAC in Eq. (59)) must add up to unity.

In order to change the units from physical quantity of agricicultural or industrial goods purchased per capita to the total quantity purchased by each group, we multiply the quantities derived in the demand equations by the numbers of individuals in the groups:

$$TCAA_i = (PCAA_i)\ (PEA_i) \tag{73}$$

where

TCAA = Total Consumption of Agricultural goods by the population employed in Agriculture, units per year,

PCAA = Per capita Consumption of Agricultural goods by the population employed in Agriculture, units per individual per year, and

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals.

$$TCAG_i = (PCAG_i)\ (PEG_i) \tag{74}$$

where

TCAG = Total Consumption of Agricultural products by Government employees, units per year,

PCAG = Per capita Consumption of Agricultural goods by Government employees, units per individual per year, and

PEG = Population Employed by Government, number of individuals.

$$TCAK_i = (PCAK_i)\ (PØKI_i) \tag{75}$$

where

TCAK = Total Consumption of Agricultural products by owners of c(K)apital goods in private industry, units per year,

PCAK = Per capita Consumption of Agricultural goods by c(K)apitalists, units per individual per year, and

PØKI = Population Øwning the c(K)apital invested in private Industry, number of individuals.

$$TCAI_i = (PCAI_i)\ (PEI_i) \tag{76}$$

where

TCAI = Total Consumption of Agricultural goods by the population employed in Industry, units per year,

PCAI = Per capita Consumption of Agricultural goods by Industrial employees, units per individual per year, and

PEI = Population Employed in private Industry, number of individuals.

$$TCAU_i = (PCAU_i)\ (PU_i) \tag{77}$$

where

TCAU = Total Consumption of Agricultural products by the Unemployed, units per year,

PCAU = Per capita Consumption of Agricultural goods by the Unemployed, units per year, and

PU = Population Unemployed, number of individuals.

$$TCIA_i = (PCIA_i)\ (PEA_i) \tag{78}$$

where

TCIA = Total Consumption of Industrial goods by the population employed in Agriculture, units per year,

PCIA = Per capita Consumption of Industrial goods by the population employed in Agriculture, units per individual per year, and

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals.

$$TCIG_i = (PCIG_i)\ (PEG_i) \tag{79}$$

where

TCIG = Total Consumption of Industrial goods by Government employees, units per year,

PCIG = Per capita Consumption of Industrial goods by Government employees, units per individual per year, and

PEG = Population Employed by Government, number of individuals.

$$TCIK_i = (PCIK_i)\ (PØKI_i) \tag{80}$$

where

TCIK = Total Consumption of Industrial goods by the owners of c(K)apital equipment in industry, units per year,

PCIK = Per capita Consumption of Industrial goods by c(K)apitalists, units per individual per year, and

PØKI = Population Øwning the c(K)apital invested in private Industry, number of individuals.

$$TCII_i = (PCII_i)\ (PEI_i) \tag{81}$$

where

TCII = Total Consumption of Industrial goods by the population employed in Industry, units per year,

PCII = Per capita Consumption of Industrial goods by Industrial employees, units per individual per year, and

PEI = Population Employed in private Industry, number of individuals.

$$TCIU_i = (PCIU_i)\ (PU_i) \tag{82}$$

where

TCIU = Total Consumption of Industrial goods by the Unemployed, units per year,

PCIU = Per capita Consumption of Industrial goods by the Unemployed, units per year, and

PU = Population Unemployed, number of individuals.

Having calculated the consumption of each group, we now add the quantities of each product to determine overall consumption. For industrial goods this is

$$TCI\emptyset_i = TCIA_i + TCIG_i + TCIK_i + TCII_i + TCIU_i \tag{83}$$

where

TCIØ = Total Consumption of Industrial Øutput, units per year,

TCIA = Total Consumption of Industrial goods by the population employed in Agriculture, units per year,

TCIG = Total Consumption of Industrial goods by Government employees, units per year,

TCIK = Total Consumption of Industrial goods by the owners of c(K)apital equipment in industry, units per year,

TCII = Total Consumption of Industrial goods by the population employed in private Industry, units per year, and

TCIU = Total Consumption of Industrial goods by the Unemployed, units per year.

Only a fraction of the goods will be produced locally in the Northeast.

For agricultural goods, total consumption is equal to

$$TCA\emptyset_i = TCAA_i + TCAG_i + TCAK_i + TCAI_i + TCAU_i \qquad (84)$$

where

TCAØ = Total Consumption of Agricultural Øutput in the Northeast, units per year,

TCAA = Total Consumption of Agricultural goods by the population employed in Agriculture, units per year,

TCAG = Total Consumption of Agricultural goods by Government employees, units per year,

TCAK = Total Consumption of Agricultural goods by owners of c(K)apital goods in industry, units per year,

TCAI = Total Consumption of Agricultural goods by the population employed in private Industry, units per year, and

TCAU = Total Consumption of Agricultural products by the Unemployed, units per year.

In Section III we were forced to formulate equations for investment in agriculture, because we related the population that could be supported in agriculture to the amount of land under cultivation, and the amount of land under cultivation to the capital stock of arable land. Although the stock of capital in private industry (KI) was used as a dependent variable in the production function for industrial output, we have not had to derive the equations for its

formulation until now. We adopt four main assumptions in this derivation. (1) Capital, once created, is immobile. Capital invested in agriculture cannot be transferred to industry and vice versa. (2) Industrial capital can be created both by private entrepreneurs (the capitalists) and by the government, but not by any of the other groups in the population. (3) The government, although it does create industrial capital, does not share in the returns from its use. As do farmers in agriculture, so private entrepreneurs in industry appropriate all the income that results from public investment. (4) The single, homogeneous industrial good can serve equally well for investment of the capitalists. We state their investment as being equal to a constant fraction (APIKC) of their purchases of industrial goods.

$$IKI_i = (APIKC)\ (EI\emptyset K_i) \tag{20}$$

where

IKI = Investment by private entrepreneurs in c(K)apital in Industry, baht per year,

APIKC = Average Propensity to Invest in c(K)apital in industry, a Constant, and

EIØK = Expenditures on Industrial Øutput by the owners of the c(K)apital invested in industry, baht per year.

It might also be desirable to relate the investment of capitalists to the profits that they derive, in which case Eq. (20) will have to be augmented to include a variable measuring total return (YKI). But for the moment we assume that capitalists invest out of disposable income rather than out of total receipts.

The expenditures of entrepreneurs on industrial goods are

$$EI\emptyset K_i = (TCIK_i)\ (DPI\emptyset_i) \tag{98}$$

where

EIØK = Expenditures on Industrial Øutput by the owners of the c(K)apital invested in industry, baht per year,

TCIK = Total Consumption of Industrial goods by the owners of c(K)apital equipment in industry, units per year, and

DPIØ = Domestic Price of Industrial Øutput, baht per unit.

The capital invested by private entrepreneurs accumulates with the passage of time:

$$CIKI_i = CIKI_{i-1} + IKI_i \tag{21}$$

where

CIKI = Cumulative Investment of private c(K)apital in Industry, baht, and

IKI = Investment by private entrepreneurs in the c(K)apital in Industry, baht.

Public investment is treated in the same manner. The periodic contribution of the government to the stock of industrial capital (IGKI) is equal to its expenditure, since both are in monetary terms:

$$IGKI_i = EGKI_i \tag{18}$$

where

IGKI = Investment by Government in the c(K)apital of Industry, baht, and

EGKI = Expenditures by Government increasing the c(K)apital stock of Industry, baht.

Government investment in industry is also accumulated to arrive at the government contribution:

$$CIGKI_i = CIGKI_{i-1} + IGKI_i \tag{19}$$

where

CIGKI = Cumulative Investment of Government in the c(K)apital of Industry, baht, and

IGKI = Investment by Government in the c(K)apital of Industry, baht.

In order to determine the capital stock of industry, the cumulative investment of the government is added to that of private entrepreneurs and to the capital stock initially existing, and the cumulative amount of depreciation is subtracted.

$$KI_i = KIEB + CIGKI_i + CIKI_i - CDKI_i \qquad (24)$$

where

KI = total stock of c(K)apital in Industry, baht,

KIEB = stock of c(K)apital in Industry Existing in the Base year, baht,

CIGKI = Cumulative Investment of Government in c(K)apital of Industry, baht,

CIKI = Cumulative Investment of private c(K)apital in Industry, baht, and

CDKI = Cumulative Depreciation of c(K)apital in Industry, baht.

The cumulative depreciation is the sum of regular amounts

$$CDKI_i = CDKI_{i-1} + DKI_i \qquad (23)$$

where

CDKI = Cumulative Depreciation of c(K)apital in Industry, baht, and

DKI = yearly Depreciation of c(K)apital in Industry, baht.

The periodic amount of depreciation is assumed to be a constant fraction of the amount of capital in existence at the end of the previous period.

$$DKI_i = (DRKI)\ (KI_{i-1}) \tag{22}$$

where

DKI = yearly Depreciation of c(K)apital in Industry, baht,

DRKI = Depreciation Rate for c(K)apital in Industry, a fraction, and

KI = total stock of c(K)apital in Industry, baht.

In this section we have formulated equations for the earned incomes of each of the groups in the population and for their expenditures on each of the two kinds of goods available. All groups except the owners of the capital goods in the modern sector consume what they purchase; the latter consume part, and invest the remainder of their purchases of industrial goods in their businesses. Earned incomes and expenditures are not likely to be equal, for taxes reduce the first and transfers may affect either the first or the second. Transfers will be considered in the next section, as will aggregate measures of economic activity in the Northeast and the Northeast's trade with the rest of the nation.

VI. THE MODEL: TRANSFERS AND TRADE

Transfers must be included in the model so that receipts and disbursements for each population group can be brought more or less into balance, and so that we can have a measure of burden, allowing us to estimate each group's contribution to, and benefit from, economic development. This inclusion is necessary even though transfers do not bulk large in amount or even in proportion to incomes except for the unemployed.

Accounting for transfers makes it possible to relate the incomes of the different groups to their expenditures. The disposable income of the population employed in agriculture is equal to the income generated in the sector, plus any gifts from those who emigrated from the villages to find employment in government, industry, or outside the region, less any gifts which those employed in agriculture make to the unemployed, and the taxes that they pay directly to the government.

$$DYPEA_i = YPEA_i - TPAU_i - TXPEA_i + TPGA_i + TPIA_i + TPEM \qquad (56)$$

where

DYPEA = Disposable i(Y)ncome of the Population Employed in Agriculture, baht per year,

YPEA = annual earned i(Y)ncome of the Population Employed in Agriculture, baht per year,

TPAU = Transfer Payments for those employed in Agriculture to those Unemployed, baht per year,

TXPEA = TaXes collected directly from the Population Employed in Agriculture, baht per year,

TPGA = Transfer Payments from the population employed by Government to that employed in Agriculture, baht per year,

TPIA = Transfer Payments from the population employed in private Industry to that employed in Agriculture, baht per year, and

TPEM = Transfer Payments from ÉMigrés to the population employed in agriculture, baht per year.

Transfer payments are considered later in this section, and taxes will be considered in the next.

The disposable income of government employees, equal to the total income that they receive from the government, less any taxes that they pay, and less any funds that they send to villagers or to the unemployed, is determined as follows:

$$DYPEG_i = YPEG_i - TPGA_i - TPGU_i - TXPEG_i \qquad (45)$$

where

DYPEG = Disposable i(Y)ncome of the Population Employed by Government, baht per year,

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year,

TPGA = Transfer Payments from the population employed by Government to that employed in Agriculture, baht per year,

TPGU = Transfer Payments from Government employees to the Unemployed, baht per year, and

TXPEG = TaXes levied on the Population Employed by Government, baht per year.

The disposable income of the population employed in industry is equal to its total income, less transfers to the population employed in agriculture and to the unemployed, and less taxes -- with the addition of one term that will be explained when we deal with government policy:

$$DYPEI_i = YPEI_i - TPIA_i - TPIU_i - TXPEI_i + IDRGP_i \qquad (50)$$

where

DYPEI = Disposable i(Y)ncome of the Population Employed in private Industry, baht per year,

YPEI = annual earned i(Y)ncome of the Population Employed in Industry, baht per year,

TPIA = Transfer Payments from the population employed in Industry to that employed in Agriculture, baht per year,

TPIU = Transfer Payments from the population employed in Industry to the Unemployed, baht per year,

TXPEI = TaXes levied on the Population Employed by private Industry, baht per year, and

IDRGP = Government Investment designed to produce a Decline in the Rate of Growth of the Population, baht per year.

The owners of the capital goods in industry, since they are largely an unrelated urban group, are assumed not to make donations to the population employed in agriculture or to the unemployed. The capitalists' disposable income is therefore equal to their total income less the taxes that they pay.

$$DYPKI = YKI_i - TXPKI_i \qquad (53)$$

where

DYPKI = Disposable i(Y)ncome of the Population owning the c(K)apital goods in Industry,

YKI = i(Y)ncome of those owning the c(K)apital in Industry, baht per year, and

TXPKI = TaXes on the Population owning the c(K)apital in Industry, baht per year.

For the final group, the unemployed, disposable income is equal to the sum of the gifts from those employed in the agricultural sector, those employed by government, and those employed in industry:

$$DYPU_i = TPGU_i + TPIU_i + TPAU_i \tag{57}$$

where

DYPU = Disposable i(Y)ncome of that portion of the Population Unemployed, baht per year,

TPGU = Transfer Payments from Government employees to the Unemployed, baht per year,

TPIU = Transfer Payments from the population employed in private Industry to the Unemployed, baht per year, and

TPAU = Transfer Payments from those employed in Agriculture to those Unemployed, baht per year.

Since the levying of taxes will not be considered until the next section, the only item still undetermined in each of the five equations for disposable income is the gifts from the wealthier to the poorer members of the society. Those employed in private industry and by the government are assumed to send funds both to the agricultural population and to the unemployed. The agricultural population is also assumed to donate to the unemployed. We assume: (1) that the higher the earnings of the group, the greater the amount to be transferred; (2) that at most only a certain fraction of the group's income will be donated; and (3) that the greater the size of the group receiving the donations relative to the size of the donor group, the greater the fraction given of the donors' total income. Thus, considering donations from the population employed in agriculture to the unemployed, a very small ratio of unemployed to employed would yield a very small fraction of income transferred. A large ratio of unemployed to the population employed in agriculture would result in a larger fraction of income transferred. Thus, in Eq. (54), if PU increased from zero to PEA, transfers would increase from zero to one-half the maximum fraction TPAUC:

$$TPAU_i = \left(\frac{PU_i}{PU_i + PEA_i}\right)(YPEA_i)(TPAUC) \qquad (54)$$

where

TPAU = Transfer Payments from those employed in Agriculture to those Unemployed, baht per year,

PU = Population Unemployed, number of individuals,

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals,

YPEA = annual earned i(Y)ncome of the Population Employed in Agriculture, baht per year, and

TPAUC = maximum Transfer Payments from those employed in Agriculture to the Unemployed, as a fraction of the donors' income, a Constant.

The equations for the other transfers are formed in exactly the same way:

$$TPGA_i = \left(\frac{PEA_i}{PEA_i + PEG_i}\right)(YPEG_i)(TPGAC) \qquad (42)$$

where

TPGA = Transfer Payments from the population employed by Government to that employed in Agriculture, baht per year,

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals,

PEG = Population Employed by Government, number of individuals,

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year, and

TPGAC = maximum Transfer Payments from Government employees to those employed in Agriculture, as a fraction of the donors' income, a Constant.

$$TPGU_i = \left(\frac{PU_i}{PU_i + PEG_i}\right)(YPEG_i)(TPGUC) \qquad (43)$$

where

TPGU = Transfer Payments from Government employees to the Unemployed, baht per year,

PU = Population Unemployed, number of individuals,

PEG = Population Employed by Government, number of individuals,

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year, and

TPGUC = maximum Transfer Payments from Government employees to the Unemployed, as a fraction of the donors' income, a Constant.

$$TPIA_i = \left(\frac{PEA_i}{PEA_i + PEI_i}\right)(YPEI_i)(TPIAC) \qquad (47)$$

where

TPIA = Transfer Payments from the population employed in Industry to that employed in Agriculture, baht per year,

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals,

PEI = Population Employed in private Industry, number of individuals,

YPEI = annual earned i(Y)ncome of the Population Employed in private Industry, baht per year, and

TPIAC = maximum Transfer Payments from the population employed in Industry to the population employed in Agriculture, as a fraction of the donors' income, a Constant.

$$TPIU_i = \left(\frac{PU_i}{PU_i + PEI_i}\right)(YPEI_i)(TPIUC) \qquad (48)$$

where

TPIU = Transfer Payments from the population employed in private Industry to the Unemployed, baht per year,

PU = Population Unemployed, number of individuals,

PEI = Population Employed in private Industry, number of individuals,

YPEI = annual earned i(Y)ncome of the Population Employed in private Industry, baht per year, and

TPIUC = maximum Transfer Payments from the population employed in Industry to the Unemployed, as a fraction of the donors' income, a Constant.

These five equations cover gifts: two groups give (those employed in private industry and those employed by government); one group both gives and receives (those employed in agriculture); and one group receives (the unemployed). Except for the last group, we do not expect the sums to be a large fraction of their incomes.

Whereas the unemployed share greatly in transfers, they contribute little to trade. As the unemployed have much lower disposable incomes than the employed, and as they are, hopefully, in smaller numbers, they add neither to output nor substantially to demand.

The agricultural sector provides the total exports of goods from the region. At present, and at least in the near future, consumption of agricultural products in the Northeast is less than output. The exports from the region, in value terms, are equal to:

$$EA\emptyset X_i = (\emptyset AS_i - TCA\emptyset_i)\ (DPA\emptyset_i) \tag{85}$$

where

EAØX = Expenditures on Agricultural Øutput eXported from the Northeast, baht per year,

ØAS = Øutput of the Agricultural Sector, units per year,

TCAØ = Total Consumption of Agricultural Øutput in the Northeast, units per year, and

DPAØ = Domestic Price of Agricultural Øutput, baht per year.

The revenues from the export of rice and other agricultural goods help pay for the industrial goods that the Northeast must import. Only a portion of the modern goods and services that Northeasterners consume is at present produced within the region. This portion (FIØN) has already appeared in Eq. (30), expressing the entrepreneurs' collective output decision. Entrepreneurs in the Northeast observe total consumption of the goods produced in the modern sector and then decide to supply a fraction (FIØN) themselves. It is a relatively simple matter statistically to estimate this fraction, as of an instant in time. It is extremely difficult, however, to predict what will happen to this fraction with the passage of time, and even more difficult to formulate a mathematical expression for it.

Theoretically we can imagine the fraction of modern goods and services consumed that was produced within the region to be either increasing or decreasing with development. If a consequence of economic development were a substantial reduction in the costs of communication and transportation, consumers in remote regions such as the Northeast might be attracted to and deluged with sophisticated goods produced and promoted in Bangkok or abroad. Unsophisticated, locally produced goods, would be displaced, and the fraction (FIØN) would decline. Production might, however, be initiated in the Northeast if a consequence of economic development were an expansion of the market for goods whose economies of scale in production had formerly outweighed costs of transport within Thailand. The number of producers might grow from, say, one in Bangkok to one each in Bangkok, the North, the Northeast, and the South. In this case, the fraction of total demand in the Northeast met by local production would conceivably increase from zero to unity.

If economic theory does not help us, what can we say? We can probably say that the fraction FIØN will not change rapidly or

radically. FIØN is not expected to decrease so markedly that the volume of modern goods and services produced locally actually declines, nor to increase so rapidly that the volume imported from other regions of Thailand actually declines. Local and extra-regional producers would probably share any increase in sales within the Northeast.

The effect of migration on the labor force in the Northeast is the final consideration in determining FIØN. If there were no migration from the region in the model and FIØN were held constant, unemployment would undoubtedly be very high. If migration were permitted and FIØN were allowed to increase, unemployment would probably disappear. Both these alternatives are unlikely, and the second has already been precluded by the assumption, in Section III, that the resident population of the Northeast grows at the same rate as that of Thailand as a whole. In the model, there can be only as many emigrants from the Northeast as there are immigrants from other regions. Given this stipulation, we believe that FIØN will exhibit a gentle upward trend. The fraction will take on some initial value (FIØNC1), to be estimated statistically, and then will be assumed to increase through time at some rate (FIØNC2) according to the equation:

$$\mathrm{FI\O N}_i = (\mathrm{FI\O NC1})\ e^{(\mathrm{FI\O NC2})\ (\mathrm{TEBS}_i)} \tag{29}$$

where

FIØN = Fraction of Industrial Øutput consumed that is produced in the Northeast, dimensionless,

FIØN1,2 = coefficients used in determining that Fraction of the Industrial Øutput consumed that is produced in the Northeast, Constants, dimensionless, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

This rate will depend upon the rates of growth of firms and of their capital. If we were to assume that firms always produced at minimum average cost, we could relate this rate precisely to these two

variables; but we are unwilling to do this since it would vitiate one policy instrument. Rather we shall try to determine the implications of different values of the change in the fraction of industrial goods produced locally, perhaps setting it so that the price of industrial goods does not change too markedly. If the price changed too markedly, competing goods produced elsewhere in Thailand might displace, or be displaced by, local output.

When the private entrepreneurs decide at what rate to produce, they do not use the most recent estimate of consumption (TCIØ) but an average (TCIAU). This average is calculated in the same manner as the average wage rate, with the most recent observation carrying the greatest weight.

$$TCIAV_i = (TCIAV_{i-1})\ (TCIC1) + (TCIØ_i)\ (TCIC2) \qquad (29A)$$

where

TCIAV = Total Consumption of Industrial output, AVeraged, units per year,

TCIØ = Total Consumption of Industrial Output, units per year, and

TCIC1,2 = coefficients used in determining the average Total Consumption of Industrial output, Constants.

Some elements are more or less in balance, and should be made explicit. First are items produced in the Northeast and ultimately exported from Thailand, as well as items imported into Thailand and ultimately used in the Northeast. The only exports are agricultural goods; part of the income from these accrues to the government. We assume that the government spends this revenue entirely on imports of capital goods. These in turn are allocated to investment in either the agricultural or the industrial sector. The value of the exported agricultural products is thus assumed to be returned to the agricultural sector through government investment in agriculture -- there to yield rent to the population employed in agriculture, and to the

capitalists through the government's investment in capital goods in the industrial sector. There is thus an unmeasured transfer of resources from the agricultural to the industrial sector.

The second set of variables that are more or less in balance is the total inflows to and outflows from the Northeast. Taking the direction indicated by the flow of money, cash inflows into the region come about as the result of agricultural outflows, gifts from émigrés and government expenditures:

$$EXNE_i = EA\emptyset X_i + TPEM + EG_i \tag{92}$$

where

EXNE = payments for <u>EX</u>ports from the <u>N</u>orth<u>E</u>ast, baht per year,

EAØX = <u>E</u>xpenditures on <u>A</u>gricultural <u>O</u>utput purchased by the government for e<u>X</u>port, baht per year,

TPEM = <u>T</u>ransfer <u>P</u>ayments from <u>ÉM</u>igrés to the population employed in agriculture, baht per year, and

EG = <u>E</u>xpenditures by the <u>G</u>overnment in the Northeast, baht per year.

Cash flows out for the purchase of industrial goods not produced in the Northeast and for taxes to the central authority.

$$IMNE_i = VIMI_i + (RG_i - TXAX_i) \tag{93}$$

where

IMNE = payments for <u>IM</u>ports into the <u>N</u>orth<u>E</u>ast, baht per year,

VIMI = <u>V</u>alue of the <u>I</u>mports of <u>I</u>ndustrial goods into the Northeast, baht per year,

RG = total <u>R</u>evenues of the <u>G</u>overnment derived from the Northeast, baht per year, and

TXAX = <u>T</u>a<u>X</u>es collected on <u>A</u>gricultural e<u>X</u>ports from the Northeast, baht per year

and

$$VIMI_i = (TCIØ_i - ØIS_i)\ (DPIØ_i) \qquad (87)$$

where

VIMI = Value of the IMports of Industrial goods into the Northeast, baht per year,

TCIØ = Total Consumption of Industrial Øutput, units per year,

ØIS = Øutput of the private Industrial Sector, units per year, and

DPIØ = Domestic Price of Industrial Øutput, baht per year.

Any difference between the volume of cash inflows and outflows will appear as a surplus or deficit in the region's balance of payments.

$$BØPNE_i = EXNE_i - IMNE_i \qquad (94)$$

where

BØPNE = deficit (-) or surplus (+) in the Balance Øf Payments of the NorthEast, baht per year,

EXNE = payments for EXports from the NorthEast, baht per year, and

IMNE = payment for IMports into the NorthEast, baht per year.

Finally, there are four overall measures of the economic performance of the region. (1) Total disposable income:

$$DYTNE_i = DYPEG_i + DYPEA_i + DYPEI_i + DYPKI_i + DYPU_i \qquad (96)$$

where

DYTNE = Disposable i(Y)ncome, Total, of the population in the NorthEast, baht per year,

DYPEG = Disposable i(Y)ncome of the Population Employed by Government, baht per year,

DYPEA = Disposable i(Y)ncome of the Population Employed in Agriculture, baht per year,

DYPEI = Disposable i(Y)ncome of the Population Employed in private Industry, baht per year,

DYPKI = Disposable i(Y)ncome of the Population owning the c(K)apital goods in Industry, baht per year, and

DYPU = Disposable i(Y)ncome of that portion of the Population Unemployed, baht per year.

(2) Total expenditures by consumers:

$$ETNE_i = (TCIØ_i)\ (DPIØ_i) + (TCAØ_i)\ (DPAØ_i) \qquad (95)$$

where

ETNE = Expenditures (Total) by consumers in the NorthEast, baht per year,

TCIØ = Total Consumption of Industrial Øutput, units per year,

DPIØ = Domestic Price of Industrial Øutput, baht per unit,

TCAØ = Total Consumption of Agricultural Øutput in the Northeast, units per year, and

DPAØ = Domestic Price of Agricultural Øutput, baht per unit.

(3) Total earned income:

$$YTNE_i = YPEG_i + YPEA_i + YPEI_i + YKI \qquad (91)$$

where

YTNE = i(Y)ncome, Total, for the NorthEast, baht per year,

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year,

YPEA = earned i(Y)ncome of the Population Employed in Agriculture, baht per year,

YPEI = earned i(Y)ncome of the Population Employed in private Industry, baht per year, and

YKI = i(Y)ncome of those owning the c(K)apital in Industry, baht per year.

(4) Per capita (earned) income:

$$YPCNE_i = \frac{YTNE_i}{PT_i} \tag{97}$$

where

YPCNE = i(Y)ncome Per Capita in the NorthEast, baht per person per year,

YTNE = i(Y)ncome, Total, for the NorthEast, baht per year, and

PT = Population, Total number of individuals in the Northeast.

These measures of the performance of the Northeast will improve as its economy produces more goods, and as the government spends more in the region. (Government expenditures are considered in the next section.) There are different limitations to improving the output of the Northeast's two products. In agriculture the amount of land brought under cultivation limits the amount of agricultural output. There is likely to continue to be enough labor to carry out cultivation, so output in agriculture can be increased only by augmenting the amount of tillable land and by bringing tillable land under cultivation. The former is accomplished through government investment and the latter takes place automatically through time.

In private industry, there are not two but three inputs -- industrial labor, capital goods, and "entrepreneurship" (identified specifically as the number of firms in existence). It is conceivable that any one of these inputs could be in relative scarcity, but we

anticipate that there will always be enough labor to operate the capital equipment. The stock of capital goods will increase through investment by private businessmen; entrepreneurship will grow through the natural increase in the number of firms. Moreover, as in agriculture, the government can also augment each of these inputs.

We have formulated roles for the government in both sectors of the Northeast's economy. We shall now consider the ways in which the government may intervene.

VII. THE MODEL: INSTRUMENTS OF GOVERNMENT POLICY

As one of the purposes of constructing a mathematical model of the economic development of the Northeast is to examine the possible effects of different government policies, the policy instruments must be built into the system. The values for all the instruments of government are exogenous to the model. In a political system the various policy instruments are determined through the operation of the system's other elements, but as our model is an economic one, the political forces remain outside.

We shall identify three different types of policy instruments: the collection of revenues, the expending of funds, and controls over institutions. To carry out its functions, a government will appropriate resources from the rest of the economy. These are almost always collected in the form of money. The direct appropriation of resources -- such as human through military and civilain conscripts, and capital and commodities through seizure -- seems to be of little relevance to Thailand.

The first class of government revenues is taxes, which we define in terms of the group upon which they impinge. We shall consider only direct taxes and one indirect tax, the "rice premium." Indirect taxes of whose amount or incidence we have no evidence will be neglected. Since we divided the employed population into four groups, we also divide direct taxes into four categories: (1) Direct taxes collected from the population employed in agriculture (TXPEA); (2) Taxes collected from the population employed in the industrial sector (TXPEI); (3) Taxes collected from civil servants (TXPEG); and (4) Taxes collected from capitalists (TXKI).

Direct taxes on the first three groups are based on the numbers that make up the group; in other words, the taxes are assumed to be of the nature of head taxes or poll taxes -- a fixed amount for each individual. As the amounts collected from these three groups are small, relating taxes to income would make little difference. For those occupied within the traditional sector the tax is

$$TXPEA_i = (PEA_i)\ (TXPAC) \tag{55}$$

where

TXPEA = TaXes collected directly from the Population Employed in Agriculture, baht per year,

PEA = Population Employed in the Agricultural (traditional) sector, number of individuals, and

TXPAC = TaX rate on the Population employed in Agriculture, baht per person per year, a Constant.

For those employed by private industry, the tax is

$$TXPEI_i = (PEI_i)\ (TXPIC) \tag{49}$$

where

TXPEI = direct TaXes levied on the Population Employed in private Industry, baht per year,

PEI = Population Employed in private Industry, number of individuals, and

TXPIC = TaX rate on the Population employed in private Industry, baht per person per year, a Constant.

The direct taxes of civil servants are also assumed to be proportional to the population employed:

$$TXPEG_i = (PEG_i)\ (TXPGC) \tag{44}$$

where

TXPEG = direct TaXes levied on the Population Employed by Government, baht per year,

PEG = Population Employed by Government, number of individuals,

TXPGC = TaX rate on the Population employed by Government, baht per person per year, a Constant.

The fourth group, private entrepreneurs, are assumed to pay taxes in proportion to their income: if their incomes are high, the taxes imposed on them will also be high; if low, then low.

$$TXPKI_i = (YKI_i)\ (TXPKC) \qquad (52)$$

where

TXPKI = direct TaXes on the Population owning the c(K)apital in Industry, baht per year,

YKI = i(Y)ncome of those owning the c(K)apital in Industry, baht per year, and

TXPKC = TaX rate on the income of the Population owning c(K)apital goods, dimensionless, a Constant.

Besides these general taxes, levied on occupational groups, we shall identify one other specific tax -- the so-called "rice premium." The rice premium is an export tax on rice. The Thai government purchases a substantial quantity of rice (RICEX) at its established price (DPAØ), for export to foreign countries. To these it sells at the world price, retaining the difference, the "rice premium." It is assumed that the government will continue this policy so long as this much (RICEX) is available. If production in the Northeast is less than domestic consumption plus the customary export, then the government will purchase only the surplus above consumption. The revenues will therefore vary according to the following equations:

$$TXAX_i = \begin{cases} (RICEX_i)\ (RICEP);\ \text{if}\ (RICEX_i) \leq (OAS_i - TCAØ_i) \\ (OAS_i - TCAØ_i)\ (RICEP);\ \text{if}\ (RICEX) > (ØAS_i - (TCAØ_i) \end{cases} \qquad (86)$$

where

TXAX = TaXes collected on Agricultural eXports from the Northeast, baht per year,

RICEX = RICE eXports in the base year, tons per year, a constant.

RICEP = RICE Premium, baht per unit of agricultural output,

ØAS = Output of the Agricultural Sector, units per year,

TCAØ = Total Consumption of Agricultural Øutput in the Northeast, units per year.

Since the government, as marginal buyer, has considerable influence over the domestic price of rice, we define this price as the residual after the rice premium has been deducted from the world price:

$$DPA\O_i = FPA\O - RICEP \tag{25}$$

where

DPAØ = Domestic Price of Agricultural Øutput, baht per unit,

FPAØ = Foreign Price of the Agricultural Øutput, baht per unit, and

RICEP = RICE Premium, baht per unit of agricultural output.

The incidence of the "rice premium" falls primarily upon the agricultural section. However, it is kept separate from the other taxes, as it is determined by different factors.

The final source of government revenue for the Northeast is foreign aid (FAID). This and the previous five components yield total government revenues (less indirect taxes):

$$RG_i = TXAX_i + TXPEG_i + TXPKI_i + TXPEI_i + TXPEA_i + FAID \tag{88}$$

where

RG = Revenues of the Thai Government derived directly from the Northeast, baht per year,

TXAX = TaXes collected on Agricultural eXports from the Northeast, baht per year,

TXPEG = direct TaXes levied on the Population Employed by Government, baht per year,

TXPKI = direct TaXes on the Population owning the c(K)apital goods in Industry, baht per year,

TXPEI = direct TaXes levied on the Population Employed in private Industry, baht per year,

TXPEA = TaXes collected directly from the Population Employed in Agriculture, baht per year, and

FAID = Foreign AID received by the Thai government for expenditure in the Northeast, baht per year.

Government expenditures in the Northeast (EG) are divided into four categories: (1) those that result in an investment in the agricultural sector (EGA), (2) those that result in an investment in private industry (EGKI), (3) salaries of civil servants (YPEG), and (4) investments in activities designed to alter the rate of growth of the population (IDRGP). In total, these are

$$EG_i = EGA_i + EGKI_i + YPEG_i + IDRGP_i \tag{89}$$

where

EG = Expenditures of the Thai Government in the Northeast, baht per year,

EGA = Expenditures by the Government in Agriculture, baht per year,

EGKI = Expenditures by the Government on c(K)apital goods in Industry, baht per year,

YPEG = earned i(Y)ncome of the Population Employed by Government, baht per year, and

IDRGP = government Investment designed to produce a Decline in the Rate of Growth of the Population, baht per year.

The effects of government expenditures in agriculture and industry have already been discussed, but the magnitudes of these expenditures have not been determined. For agriculture, we assume that, starting from some initial value (EGAC1), government expenditures increase steadily at an annual rate (EGAC), according to the equation

$$EGA_i = (EGAC1)\ e^{(EGAC)\ (TEBS_i)} \tag{5A}$$

where

EGA = Expenditures by Government in Agriculture, baht per year,

EGAC1, EGAC = coefficients used in determining the initial level and rate of increase of Expenditures by Government in Agriculture, Constants, various dimensions, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

The equation for the level of government expenditures for industry is of exactly the same form:

$$EGKI_i = (EGKIC1)\ e^{(EGKIC)\ (TEBS_i)} \tag{17A}$$

where

EGKI = Expenditures by the Government in c(K)apital goods in Industry, baht per year,

EGKIC1, EGKIC = coefficients used in determining the initial level and the rate of increase of Expenditures by the Government on c(K)apital goods in Industry, baht per year, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

Government expenditures on its own employees are the product of the number of civil servants and their average wage. Both these variables (PEG and WEG) are policy instruments, although it may be agreed that WEG cannot be far behind WEI, the average wage received by the employees of the private portion of the modern sector. We do not attempt to link the two wages, however, but merely assume that the annual wage of civil servants rises at some constant rate (IWEGC) that will probably not be less than that of the society as a whole:

$$WEG_i = (WEGB)\ e^{(IWEGC)\ (TEBS_i)} \tag{39}$$

where

WEG = average Wage paid to each individual in the Employ of the Government, baht per year,

WEGB = Wage of those Employed by Government at the Beginning of the simulation, baht per individual per year,

IWEGC = annual rate of Increase in the Wage paid to those Employed by Government, dimensionless, a Constant, and

TEBS = Time Elapsed since the Beginning of the Simulation, years.

The production function for government remains implicit, for we assume that the employees in government "produce" the government investments in the agricultural and industrial sectors, and "produce" the programs by which the government influences the growth of the number of firms and of the population. Thus, labor is the only factor in the governmental production function, and the amount of labor which the government has on hand (equal to the number of civil servants) is always assumed to be adequate to carry out its policies.

"Family planning" is the last item of government expenditure, and the next-to-last policy instrument. When a government first begins to influence the size of the population, the effects are usually, deliberately or not, to increase its size. By encouraging immigration, improving health and nutrition, and promoting order, the government promotes a rapid rise in the number of citizens. But we assume, so far as Thailand is concerned, that this stage is past, and that any future government activities will be directed toward reducing the population's growth rate. We can have no clear idea of the relation between the expenditures the government makes and the results which it obtains, and we therefore assume the most simple type of equation:

$$DSDRG_i = (IDRGC)\ (IDRGP_i) \tag{15A}$$

where

DSDRG = additional Decline in the Standard deviation, measuring the Decline in the Rate of Growth of the population brought about by government expenditures on family planning, dimensionless,

IDRGC = constant relating Investment in family planning to the Decline in the Rate of Growth of the population, a Constant, years per baht, and

IDRGP = government Investment designed to produce a Decline in the Rate of Growth of the Population, baht per year.

The coefficient (IDRGC) is not expected to be large, for it appears that a reduction in the birth rate through government intervention is very hard to accomplish. It is usually accompanied, if not preceded, by shifts in political power and income from the traditional groups of society (those living in the agricultural sector and religious authorities) to the modern sectors (the Western-trained medical profession and civil servants). The situation in India some ten years after the inception of a national program to limit population is illustrative:

> Beset with food shortages and other difficulties associated with a population explosion, India is now setting a broad, new "extended" family planning program in motion to cut down the national birth rate from 40 to 25 per thousand within the next decade.
>
> The Indian Government is gearing up its administrative machinery for the job. As of this February, the Health Ministry has the new title of Ministry of Health and Family Planning. It has created a Department of Family Planning headed by a secretary who is assisted by a Family Planning Commissioner. They are adding the organizational means and staff to strengthen the program and tighten coordination between the central and state governments. ([453], p. 1.)
>
> India's Fourth Five-Year Plan, covering 1966-71, provides the rupee equivalent of about $210 million for family planning. This is more than double the Third Plan ceiling. The highest priority, equal to increasing the agricultural production, is assigned to it. (Ibid., p. 2.)

> A substantial training program has been drawn up to meet the needs of a greatly enlarged field staff. (Ibid., p. 19.)
>
> The Health Ministry's Department of Family Planning has been authorized to recruit 200 physicians for a special cadre to help meet local medical staff needs, especially for lady doctors. Unusually high salary levels are being established to attract applicants. (Ibid., p. 10.)

As we have already accounted for the incomes of the civil servants, we therefore assume that additional government expenditures on the reduction of the birth rate are appropriated by the modern sector, specifically by those individuals who are employed therein.

Besides any reduction in the birth rate that is achieved through family planning, there may also be a natural decline in the population's growth rate (designated as SDRGP in Figure 6 of Section III), as people become aware that it is possible to control the size of their families and as the appropriate devices become available. Government expenditures on family planning will augment SDRGP:

$$SDRGP_i = (SDRGP_{i-1})\ (1 - DSDRG_i) \qquad (15B)$$

where

SDRGP = Standard deviation, measuring the quickness of Decline in the Rate of Growth of the Population, years, and

DSDRG = additional Decline in the Standard deviation, measuring the Decline in the Rate of Growth of the population brought about by government expenditures on family planning, dimensionless.

We can now calculate the regional budgetary surplus or deficit. The difference (DSGA) between the revenues collected by the government from the inhabitants of the Northeast and the expenditures made there is

$$DSGA_i = RG_i - EG_i \tag{90}$$

where

DSGA = Deficit (-) or Surplus (+) in Government Accounts for the Northeast, baht per year,

RG = Receipts of the Thai Government in the Northeast, baht per year, and

EG = Expenditures of the Thai Government in the Northeast, baht per year.

If it were possible to estimate indirect taxes, we would be better able to allocate the burdens and benefits of economic development in the Northeast; as it is, we expect DSGA to be negative and confine our comparisons primarily to yearly changes.

The final policy instrument that we identify is the number of new firms which the government permits. This number is really a combination of several instruments, including the government's import licensing program, its granting of public or private monopolies for domestic manufacture and trade, its treatment of foreigners and of its own ethnic groups, and its programs relating to credit and education. The instrument in this case will be called AFSG, the additional firms stimulated directly by the government, and will be assumed to be a fraction, NFEGC, of the number already in existence:

$$AFSG_i = (NFEGC)\ (NFI_{i-1}) \tag{12}$$

where

AFSG = Additional Firms Stimulated directly by the Government, number per year,

NFEGC = Number of new Firms Established by the Government, relative to the number already in existence, a Constant, reciprocal years, and

NFI = Number of Firms in private Industry.

The owners of the capital equipment (or of the firms that operate it) have already been assumed to maximize their profits, combining labor and capital in the most efficient way, given the stock of capital already in existence, the supply of labor, and the demand for output. Under a régime of perfect competition, whenever the return to the owners of the capital goods becomes excessive, new firms are established. Each firm would operate at the output at which minimum average cost prevailed, the number of firms being determined through entry. But in Thailand, we believe that the number of firms will be a government instrument, and will be either fewer or greater than under perfect competition. If fewer, capital and labor will be used to a greater extent than they would be if there were more firms, as each of the fewer-than-ideal number of firms operates at an output beyond that at which economies of scale cease. Each of the existing firms will employ too much labor and too much capital, "too much" being measured relative to the amount it would employ if it were producing at minimum average cost. If the number of firms were greater, the consequences would be just the reverse. But in either case the average productivity of the inputs would be lower than under perfect competition.

AFSG was defined as the addition to the total number of firms stimulated by the government. To this we add the number of firms that would be created voluntarily as a consequence of the profitability of private industry, making it proportional to entrepreneurial income:

$$AFSP_i = (NFEKC)\ (PCPKI_i) \qquad (11)$$

where

AFSP = Additional Firms Stimulated by Profits in industry, number per year,

NFEKC = Number of Firms Established as a consequence of the profitability of c(K)apital in industry, a Constant, number per baht per person, and

PCPKI = Per capita Consumption of the Population owning the c(K)apital goods employed in Industry, baht per person per year.

The total number of firms in existence is equal to the sum of those in existence previously plus those whose entry has come about through inducements of profits and government encouragement:

$$NFI_i = NFI_{i-1} + AFSP_i + AFSG_i \tag{13}$$

where

NFI = Number of Firms in the Industrial sector,

AFSP = Additional Firms Stimulated by Profits in industry, number per year, and

AFSG = Additional Firms Stimulated directly by the Government, number per year.

The above equation completes the list of instruments by which the government will influence employment, output and the distribution of income. Summarizing, the eleven instruments are combined of six sources of revenue (TXPEA, TXPEI, TXPEG, TXPKI, TXAX, and FAID), four types of government expenditure (EGA, EGKI, YPEG, and IDRGP) and the one non-financial instrument, the number of new firms the government stimulates (AFSG).

VIII. THE STATE OF THE ECONOMY IN 1960

INTRODUCTION

In the preceding five sections we have formulated a model of the economy of the Northeast of Thailand. The model is complex, composed of more than 100 equations, and because many of the equations are non-linear the model cannot be solved analytically. Although we cannot determine its general properties, we can simulate the model's behavior under different circumstances through the use of a computer. By applying this method we will first attempt to define the state of the Northeast's economy at one date in the past; second, to estimate present trends; and finally to imagine what might be the future policies of the Thai government. In terms of the mathematical model this means specifying the initial conditions and the parameter values (which we will do now) and then generating future values of the dependent variables (which we will do in Sections IX, X, and XI).

As a point of departure for the simulation, we chose a recent date -- one since World War II, when statistics began to be collected on a grand scale -- and yet far enough in the past so that one could, when the data become available, compare the results of the simulation against a few years of history. The year 1960 was thus chosen because it meets these general requirements and because it was the year in which a Census of Population was made.

POPULATION

In attaching numbers to the variables describing the structure of the economy of the Northeast of Thailand in the mathematical model, we start with population. The prime source is the Census of Population carried out on April 25, 1960, and published in 71 bulletins, one for each province.*

*Government of Thailand, Central Statistical Office, National Economic Development Board, Thailand Population Census: 1960, Changwad Series, Bangkok: no date.

In 1960, the population of the 15 provinces lying on the Khorat Plateau, which comprises the Northeast of Thailand, was 9,021,543 (see Table 5 in Section I). This included all persons residing in Thailand at the time of the Census except the nomadic hill tribes and foreign diplomatic and military personnel. It also included the Thai military at the places where they were stationed. Persons were counted as residents of the places in which they usually lived or slept.

In 1960 the population of the Northeast represented almost exactly one-third of that of the country as a whole, and is growing more rapidly than the rest of the country. Since the end of World War II, the birth rate has remained more or less constant while the death rate has declined substantially as the health of the population improved; as a consequence the rate of growth has increased. In 1940 it was 1.9 percent per year; in 1954, 2.5 percent; and in 1964-1965 at least 3.2 percent ([607] reports 3.22 percent and [128], 3.3 percent).

For the purposes of the model, the population of Northeast Thailand was divided into five groups, according to their employment: (1) workers employed in agriculture, (2) workers employed by government, (3) workers in industry, (4) owners of the capital equipment employed in industry, and (5) unemployed. In the case of the first group, employment coincides with the sector; in the case of the next three, all occupy the modern sector. The unemployed cannot be assigned to a sector.

In determining the numbers of individuals in the agricultural sector, we were not able to rely upon the Census, because its definition of agricultural households* did not include all of those actually residing in the villages and part of traditional society. Instead we took the fraction of the total of population living in the traditional sector to be equal to 0.93 (this being the fraction of all workers in

*"...an agricultural household is one that operated two or more rai, sold agricultural products valued at 2,400 baht or more, or has livestock valued at 2,400 baht or more...." [326, p. B].

the Northeast holding farm jobs [165, p. 11]). Some of these may hold jobs outside the agricultural sector for a few weeks or months during the year, but their homes remain in the villages. The population employed in agriculture is therefore equal to 8,390,035.

According to the Census, there were 90,421 government employees in the Northeast in 1960 (see Table 7). Public employees are defined as any persons who work for the government, including those in the armed forces and those who are employed in a government economic enterprise [326, p. C].* If we multiply the number of public employees by 2.63, the ratio for the modern sector of total family members to those in the family that have employment [332, Table VIII.5, p. 330], we obtain a total of 237,807, our estimate of the total number of people in the Northeast owing their support to the government.

The workers, the capitalists, and the unemployed account for the remainder of the population of the Northeast. According to the Census, there were 3,744 employers in the Northeast (see Table 7) -- an employer being defined as "...a person who operates his own economic enterprise, or engages independently in a profession or trade, and employs one or more persons...." [326, p. C]. Multiplying this by 2.63, the ratio of the total family members to those employed, we find that the population being supported through the ownership of the capital goods in industry is equal to 9,847.

From the remainder of the population we draw both the industrial workers and the unemployed. According to the Census, in 1960 there were 30,267 persons actively seeking employment (see Table 8). This included all who had looked for work in the week preceding the inquiry, both those who had been previously employed and those who were seeking their first job, but excluded any who had been ill or otherwise indisposed. The source** did not indicate which occupations the unemployed

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*In Usher's calculations of the Thai national income, he found only a little over twice as many, 210,000, employed in public administration and defense in all of Thailand, but he did not include teachers in this calculation [337, Table 5, p. 207].

**[326], Table 15, passim.

Table 7

NUMBERS OF INDIVIDUALS IN VARIOUS OCCUPATIONS IN THE NORTHEAST, BY PROVINCE, 1960

Province	Government Employees	Employers
Udon Thani	8,856	120
Nong Khai	2,989	227
Leoi	2,193	63
Sakhon Nakhon	3,210	665
Khon Kaen	7,518	441
Mahasarakham	4,003	100
Kalasin	3,010	49
Roi Et	4,504	59
Ubon Ratchathani	13,824	565
Sisaket	4,039	144
Surin	6,091	57
Nakhom Phanom	3,583	151
Chaiyaphum	3,285	223
Buriram	3,923	248
Nakhon Rat Sima	19,383	632
Northeast	90,421	3,744

Sources:
[326], Tables 1 and 16.

Table 8

EMPLOYMENT AND UNEMPLOYMENT IN THE NORTHEAST, BY PROVINCE, 1960

Province	Total Population 11 Years and Over	Economically Active	Employed	Actively Looking for Work
Udon Thani	475,022	401,220	397,639	3,581
Nong Khai	167,016	137,221	136,602	619
Leoi	134,952	113,382	112,866	516
Sakhon Nakhon	276,891	232,507	230,185	2,322
Khon Kaen	544,706	456,122	451,276	4,846
Mahasarakham	327,429	286,346	285,313	1,033
Kalasin	277,940	244,013	242,794	1,219
Roi Et	444,699	395,794	393,410	2,384
Ubon Ratchathani	742,643	632,855	627,899	4,956
Sisaket	397,776	347,895	347,351	544
Surin	385,460	330,044	328,750	1,294
Nakhom Phanom	288,988	246,594	245,540	1,054
Chaiyaphum	314,990	271,940	270,722	1,218
Buriram	376,343	321,342	318,920	2,422
Nakhon Nat Sima	711,891	596,436	594,177	2,259
Northeast	5,866,746	5,013,711	4,983,444	30,267

Sources:

[326], Table 15, "Economically and Non-economically Active Population 11 Years of Age and Over by Type of Activity ...," various pages. There is no indication whether those looking for work belong to the agricultural or nonagricultural sector.

had previously held, but we believe the occupations to have been almost entirely in the modern sector, for only 0.6 percent of the labor force of 5,013,711 (see Table 8) seems like a very small percentage of the population. We suspect that there are also, uncounted, many people living in the villages who would seek employment outside if it were readily available. The evidence that we have for this will be presented later when we discuss transfer payments among the different population groups. Once again, as in the case of the owners of the capital goods in industry, we multiply the number of unemployed by the ratio of the total family to those members employed (2.63), yielding a total population without earned income of 79,602.

We arrive at the number of people employed by industry by subtracting from the nonagricultural population those parts of it that are supported by the government (by means of the ownership of capital equipment), and those without support. The underestimation in the Census of the population employed in agriculture forces us to use this indirect method. The estimate of 304,252 persons supported through employment in private industry in the Northeast may be considerably in error. But if we consider percentage changes in industrial employment we should be less in error, for the change in employment is tied to the change in output through the production function and the latter will be estimated with more precision.

Living outside of the Northeast, mainly in Bangkok and in the tier of agricultural provinces just to the west of Loei and Chaiyaphum, there are some 170,000 émigrés, some of whom return occasionally, others permanently, to their native region ([200], Table 3, pp. 24-25). We shall not consider their numbers, but later we will consider the funds they send back to their families in the villages.

CONSUMPTION BY THE POPULATION

Proceeding from demographic to economic data, we now consider the consumption by the population. The basic source is the Household Expenditure Survey for the Northeast region, carried out in two rounds, the first in May and June, 1962, and the second in September and

October of the same year.* For purposes of the collection of the budget studies, the region was divided into two portions, villages and towns, which conform to our distinction of agricultural and non-agricultural sectors. A total of 701 questionnaires were completed in the towns, and 2,933 in the villages.** In May 1962, when the survey began, it was estimated that there were 746,000 persons living in the towns and 8,666,000 in the villages of the Northeast. This yields a fraction of the population in the modern sector of 7.9 percent, as compared with our datum for two years earlier of 7.0 percent -- about the increase that one might expect to have occurred in the space of two years as the result of migration to the towns.

The expenditures for the families in the villages and the towns in the Northeast are divided into classes of items, some of which we shall assume are produced wholly within the traditional sector and the remainder of which we shall assume are produced wholly within the modern sector. There are nine categories: food and beverages; clothing and materials; housing and furnishings; household operations; medical and personal care; transportation; reading, recreation, and education; tobacco and alcoholic drinks; and miscellaneous household expenses.*** We have not subdivided the classes, but have assigned all of the items in each class to one sector. The best division appears to be that of Table 9 for the population employed in agriculture, and Table 10 for those employed in the modern sector. Including the miscellaneous category (which contains expenditures on weddings and other ceremonies, interest, financial and legal

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*Government of Thailand, Office of the Prime Minister, National Statistical Office, Household Expenditure Survey BE2505: Northeast Region, Advance Report, Bangkok, 1963 (?) [330 in the List of Sources]. There were also three other Household Expenditure Surveys, the first in Bangkok and its suburb Thonburi [397], the third in the north and east [398], and the fourth in the central region and the south [399].

**[330], p. 83.

***[330], Tables 1.0 and 1.1, pp. 18-19: each of these classes is subdivided in greater detail: food items in Tables 8.0 and 8.1, pp. 45-51; and nonfood items in Tables 7.0 and 7.1, pp. 35-44.

Table 9

PERCENTAGE OF TOTAL OUTLAYS OF AGRICULTURAL POPULATION SPENT ON GOODS PRODUCED IN BOTH SECTORS, BY INCOME CLASS

Percentage of Total Outlays Spent On	Income Class, Baht per Family per Year: Under 3,000 (5.8 Members)	3,000-5,999 (6.3 Members)	6,000-11,999 (5.8 Members)	12,000-17,999 (6.2 Members)	18,000 and Over (6.4 Members)	All Classes (5.9 Members)
Industrial Goods						
Clothing and materials	16.2	15.6	18.7	16.7	16.0	16.6
Medical and personal care	5.1	7.1	6.6	7.4	7.3	5.8
Transportation	2.4	2.6	4.0	8.5	13.4	3.3
Reading, recreation, education	2.3	4.4	6.0	6.3	9.5	3.6
(Subtotal)	(26.0)	(29.7)	(35.3)	(38.9)	(46.2)	(29.3)
Agricultural Goods						
Food and beverages	47.9	41.0	36.7	34.2	28.3	43.8
Housing and furnishings	8.0	8.0	7.0	7.3	7.7	7.8
Household operations	2.0	3.0	2.7	2.2	3.6	2.3
Tobacco and alcohol	3.7	4.4	4.4	5.0	6.7	4.1
Miscellaneous	7.7	8.1	8.0	7.3	4.3	7.7
(Subtotal)	(69.3)	(64.5)	(58.8)	(56.0)	(50.6)	(65.7)
Gifts and Contributions	4.6	5.5	5.5	4.8	1.9	4.8
Taxes	0.1	0.3	0.4	0.3	1.3	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source:

Office of the Prime Minister, National Statistical Office, Household Expenditure Survey BE2505: Northeast Region, Advance Report, Bangkok, 1963(?), Table 1.1, "Average Monthly Income Expenditures and Net Change in Assets and Liabilities of Families, by Income Class for Villages in the Northeast Region," p. 19, and Table 6, "Average Monthly Expenditures and Value of Goods and Services Home Produced or Received Free," pp. 33-34. In the latter there is a division of expenditures on different types of goods into those purchased in the market and those produced at home; those goods which were obtained almost entirely through purchase are considered to have originated in the industrial sector.

Table 10

PERCENTAGE OF TOTAL OUTLAYS OF INDUSTRIAL POPULATION SPENT ON GOODS PRODUCED IN BOTH SECTORS, BY INCOME CLASS

Percentage of Total Outlays Spent On	Income Class, Baht per Family per Year					
	Under 3,000 (3.8 Members)	3,000-5,999 (4.4 Members)	6,000-11,999 (5.3 Members)	12,000-17,999 (6.3 Members)	18,000 and Over (7.4 Members)	All Classes (5.4 Members)
Industrial Goods						
Clothing and materials	13.9	14.4	15.4	14.6	12.8	14.1
Medical and personal care	6.6	6.7	7.5	6.8	5.7	6.5
Transportation	4.6	4.1	3.5	3.9	11.7	6.8
Reading, recreation, education	4.8	5.4	7.4	8.3	10.0	8.2
(Subtotal)	(29.9)	(30.6)	(33.8)	(33.6)	(40.2)	(35.6)
Agricultural Goods						
Food and beverages	44.5	49.6	42.6	39.7	34.3	39.4
Housing and furnishings	11.0	6.5	7.1	10.0	6.1	7.9
Household operations	5.0	4.9	5.0	5.8	6.4	5.6
Tobacco and alcohol	4.1	5.6	5.9	4.7	4.9	5.1
Miscellaneous	0.8	1.0	2.6	2.4	2.1	2.1
(Subtotal)	(65.4)	(67.6)	(63.2)	(62.6)	(53.8)	(60.0)
Gifts and Contributions	4.3	1.5	2.4	3.2	3.8	3.1
Taxes	0.4	0.3	0.6	0.6	2.2	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source:

Office of the Prime Minister, National Statistical Office, Household Expenditure Survey BE2505: Northeast Region, Advance Report, Bangkok, 1963(?), Table 1.0, p. 18.

expenses, and other occupational expenses) in the traditional sector, the proportion of the disposable income of the agricultural population spent on goods produced in their own sector diminishes from 69 percent for the lowest income group to 51 percent for the highest income group (Table 9). Similarly, for the population living in the modern sector, as income rises, there is a tendency to spend a smaller portion of income on agricultural goods -- from 65 percent for the lowest income group to 54 percent for the highest (Table 10).

In household budget studies, expenditures are usually more accurately reported than income. In the Thai survey, however, the words "income" and "expenditure" are occasionally used interchangeably, so we assume that the two variables are closely related and use the data in Tables 9 and 10 to derive estimates of the income elasticities. If we plot the fraction of the total expenditures on goods produced in the agricultural sector against per capita disposable income, by income class, for both the agricultural and nonagricultural populations, we find the relationships expressed in Fig. 10. If we fit the points with straight lines their slopes will provide measures of income elasticities. For the agricultural population, the income elasticity of demand for goods produced in their own sector is approximately 0.90; for the population in the modern sector the income elasticity for agricultural goods is 0.93. Given the roughness of the estimates and the lack of perfection of the linear fits, we shall assume that there is no appreciable difference between the income elasticities for the two population groups, and conveniently keep the income elasticity of demand for all agricultural goods constant at 0.9.

Our demand equations were formulated so that they included not only the average per capita income of the group but also the prices of both agricultural and industrial products. We must therefore estimate their elasticities as well. Considering the demand for agricultural goods, this means estimating the price elasticity for these goods themselves and the cross-elasticity for industrial goods. The price elasticity will probably be less than unity: if the price of agricultural goods were to fall, we would expect the quantities of

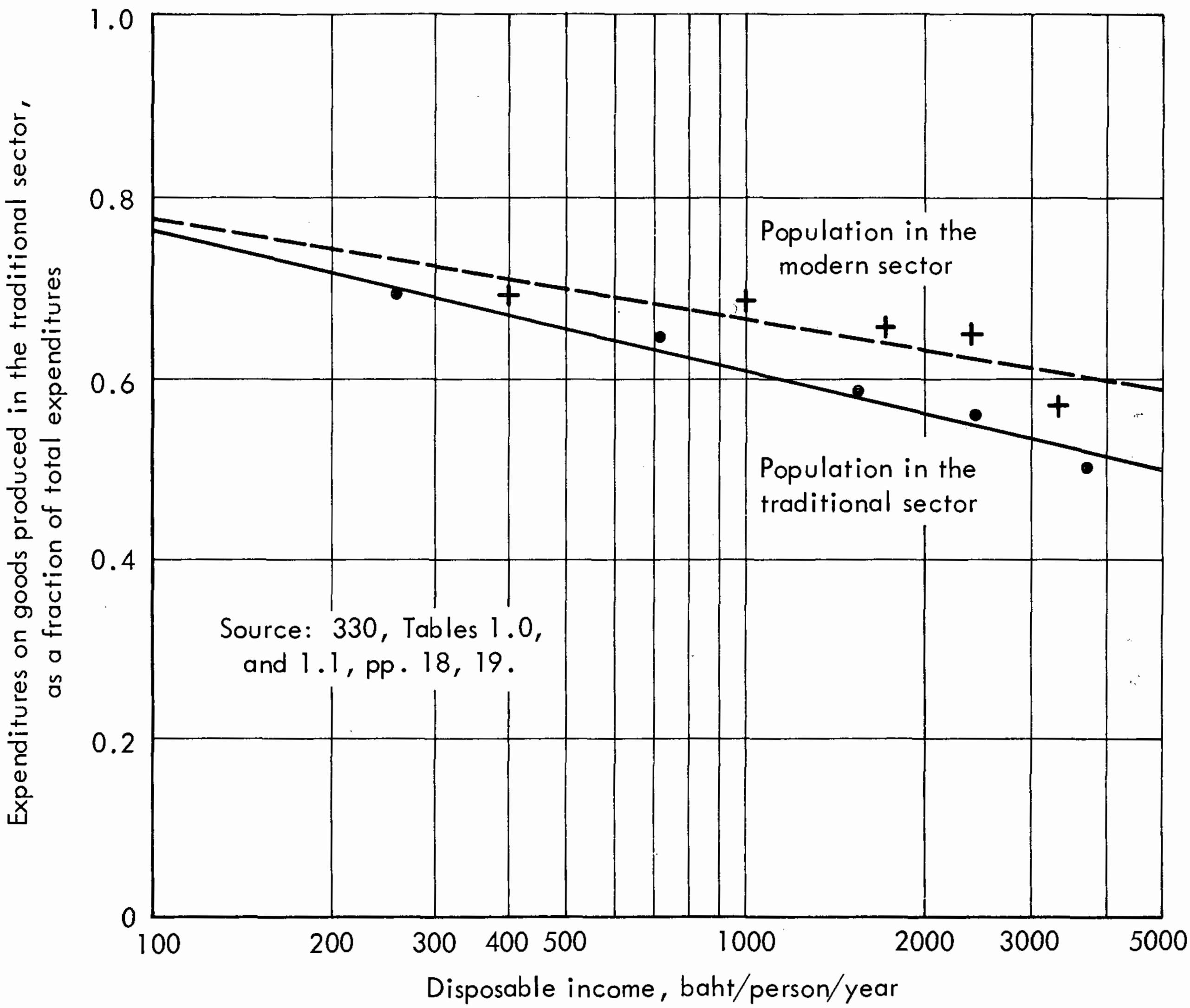

Fig. 10 — Variations in the fraction of total expenditures represented by goods produced in the traditional sector, by population group

agricultural goods purchased to increase, but in a smaller proportion. This is merely another way of saying that the demand for agricultural goods is inelastic. With no empirical data for Thailand that we know of, and little else for other underdeveloped countries [373, Table 17.7.2, p. 303], we guess the price elasticity to be -0.8.

We have no evidence as to what may be the cross-elasticity of demand, but if we make the assumption that the demand curves are homogeneous of degree zero, we can state that it must be -0.1.* We assume homogeneity of degree zero because we believe that if prices and incomes were to change in the same proportions, the quantities of each of the two goods would not change at all; that is, that there is no "money illusion."

When it comes to the three elasticities -- income elasticity, price elasticity, and cross-elasticity -- of demand for the products of the modern sector, we derive their values as a consequence of three logical steps. First, we assume that if incomes increase by some proportion (prices staying constant) expenditures (including investment) will rise by approximately the same proportion. If the income elasticity of demand for agricultural goods is less than unity, then the additional expenditure on agricultural goods will be less than proportionate to the increase in income. In order that all of the increase in income be spent, therefore, the increase in demand for industrial goods must be greater in proportion. The value of the income elasticity of demand for industrial goods will depend on the proportion of income that is spent on them, and will not be constant as the proportion changes.** As an approximation, yielding total expenditures nearly equal to total income, we set the value equal to 1.1.

The second argument that we advance is that the demand for industrial goods is price elastic. In other words, if the price of industrial goods falls relative to that of agricultural goods, the demand

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*Klein ([454], p. 94), in estimating price elasticities, found the prices of other goods never to be statistically significant, but his "goods" were more narrowly defined than ours.

**[472], [476], [477].

for industrial goods will increase in greater than equal proportions, so that the total amount to be spent on industrial goods will actually increase. Secondly, we assume that the price elasticity (with the opposite sign) is larger numerically than the income elasticity. Given that the income elasticity is 1.1, we assume that the price elasticity is -1.2.

Finally, arguing that the demand schedules are homogeneous of degree zero, we can state that the cross-elasticity of demand for agricultural goods (that is, the percentage change in the quantity of industrial goods demanded with a unit change in the price of agricultural goods) is equal to 0.1.

We assume that these elasticities apply equally to all of the various population groups. Under this assumption, groups will have similar consumption patterns if their incomes are the same. Actually, as we shall see, their incomes are quite different and therefore their consumption patterns vary accordingly. Moreover, there is no reason why the elasticities should be constant; as a matter of fact, they cannot be constant and yield expenditures equal to income for all income levels unless all the groups have exactly the same average per capita income, the initial income is expended half on agricultural goods and half on industrial goods, and the income or price changes are extremely small. If these conditions do not hold, particularly if there are wide movements in prices or substantial changes in income, we may find in the course of the simulations that incomes and expenditures do not coincide. Should the differences be small, we shall neglect them (or, equivalently, assume that they represent either saving or dissaving). If they become relatively large, we shall have to drop the demand equations for one of the products, say, agricultural goods, and substitute a new set of equations that will equate expenditures on agricultural goods to the amount of disposable income that remains after purchases of industrial goods have been determined.

Besides the two categories of goods upon which income is expended, the population also makes gifts and contributions to others and pays

taxes (see the last two rows in Tables 9 and 10). The general rule we shall follow is that expenditures are equal to disposable income, and that expenditures plus gifts, contributions, and taxes are equal to total income. The departures from this will be the crudely estimated income of the capitalists and payments to the unemployed, and the income of the population employed in agriculture, some of whose "contributions" will be included in the category of expenditures on agricultural products.

We begin by deriving the income for the population employed in agriculture. The results are summarized in Tables 11 and 12. Total family expenditures on all items average 406.46 baht per month.* Allowing for the fact that the average number of individuals in a farm family is 5.9,** the assumption that expenditures equal disposable income, and changing from a monthly to a yearly basis, we find that per capita income for the population in the agricultural sector is equal to 826.70 baht per year. From this are subtracted gifts and contributions of 1.97 baht per person per year (the derivation of this quantity will be explained later), and taxes of 1.00 baht per family per month or 2.03 bhat per person per year.*** The remainder, disposable income, is 822.69 baht per person per year.

In the same source table there is an item "income from other sources" that is not defined in the text but that does exclude wages and salaries (including the value of income from self employment), income from the sale of farm animals and other agricultural produce, and the value of any of this produce that is consumed in the home. We assume that the whole amount, equal to 9.73 baht per family per month or 19.79 baht per person per year, represents contributions from those outside the traditional sector. The contributions come from workers in industry, from government employees, and from emigrants

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*[330], Table 1.1, p. 19.

**<u>Ibid</u>.

***<u>Ibid</u>.

Table 11

PER CAPITA EXPENDITURES AND INCOME OF THE DIFFERENT POPULATION GROUPS IN THE NORTHEAST, 1960
(baht per year)

Expenditures and Income Earnings	Population Group					
	Agricultural	Industrial Employees	Government Employees	Owners of Capital in Industry	Unemployed	Total Population of the Northeast
Expenditures						
Agricultural goods	569	1,010	1,592	25,050	219	635
Industrial	254	477	811	21,971	81	298
Transfers to others	2.0 (to unemployed)	34.2 (to agricultural) 9.7 (to unemployed)	15.6 (to agricultural) 18.6 (to unemployed)	-	-	3.9
Taxes	2.0	29.0	29.0	1,030	-	4.8
Total	827	1,560	2,466	48,151	300	939
Income Earnings	806.9	1,550	2,460	47,888	-	919
Transfers from others	0.9 (from industrial employees) 0.4 (from govt. employees) 18.5 (from émigrés and others)	-	-	-	37 (from industrial employees) 55 (from govt. employees) 208 (from agricultural)	21
Total	826.7	1,550	2,460	47,888	300	939

Sources:
See text.

Table 12

TOTAL EXPENDITURES AND INCOME OF THE DIFFERENT POPULATION GROUPS IN THE NORTHEAST, 1960
(million baht per year)

Expenditures and Income Earnings	Population Group					
	Agricultural	Industrial Employees	Government Employees	Owners of Capital in Industry	Unemployed	Total Population of the Northeast
Expenditures						
Agricultural goods	4,774	307	377	246	17	5,722
Industrial	2,129	145	193	216	6	2,689
Transfers to others	16.5 (to unemployed)	7.5 (to agricultural) 2.9 (to unemployed)	3.7 (to agricultural) 4.4 (to unemployed)	-	-	35
Taxes	17	8.8	6.9	10.4	-	43
Total	6,936	472	1,585	472	23	8,489
Income Earnings	6,770	472	1,585	471	-	8,299
Transfers from others	7.5 (from industrial employees) 3.7 (from govt. employees) 155 (from émigrés and others)	-	-	-	2.9 (from industrial employees) 4.4 (from govt. employees) 16.5 (from agricultural)	190
Total	6,936	472	1,585	471	23	8,488

Sources:
See text.

and miscellaneous sources. We have independent estimates of the amounts transferred from the industrial employees and from government employees to those in the agricultural sector; the residual 155 million baht per year in total is assumed to come from the last group. The remaining 806.91 baht per person per year come from the earnings of those employed in agriculture.

Considering transfer payments within the traditional sector rather than transfer payments from the modern sector to the traditional sector, we are confronted with a paradox. If we multiply gifts and contributions (4.8 percent of total expenditures, or 39.4 baht per person per year) by the population employed in the agricultural sector (8,390,035 individuals), we obtain a total transfer payment of 330,000,000 baht per year. If we were to assume that the recipients of these contributions were given, on the average, 300 baht per person per year (this represents roughly 37 percent of the average per capita income for those who are employed), we would find that the agricultural sector alone was supporting approximately 1,100,000 persons. These would presumably be unemployed. In Table 7.1 of the Household Expenditure Survey,* "gifts and contributions" were broken down into three items: "cash contribution to organizations," "cash contribution to persons," and "food and offerings to priests." If only the cash contribution to persons is considered we find that gifts are equal to 4.83 baht per month per family, or 9.84 baht per person per year. Multiplying by the total population in the agricultural sector, we obtain a total transfer of 82,421,000 baht per year. Assuming again that each unemployed person receives 300 baht per year, this would represent an unemployment, supported by the population in the agricultural sector alone, of 270,000 persons, or, allowing for those supported by the population employed in industry and government, of well over 300,000 persons.

Yet in looking at the Census, we find that there are 30,267 persons looking for work (see Table 8), or, counting their dependents,

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*[330], p. 44.

approximately 80,000 persons in need of support. So our paradox is the following: if we base our estimate of the total unemployment in the Northeast on the transfer payments reported in the household budget study, the number of unemployed, plus their families, is three to four times as high as the figures reported in the 1960 Census. If, on the other hand, we accept the unemployment estimate reported in the Census, the amount of funds donated by the population employed in agriculture (probably almost entirely to the unemployed) is much greater than would be necessary to support those who are identified as being unemployed. In order to resolve the issue we would either have to increase the number of unemployed, thus questioning the validity of the Population Census, or reduce the amount of transfers, thus questioning the validity of the Household Expenditure Survey. We shall choose the latter course, recognizing that the initial (1960) amount of unemployment is almost certainly understated.

Having done this, if we are to balance incomes and expenditures for all the population groups, the personal gifts of the population employed in agriculture must now be reduced. Allowing for transfer payments to the unemployed both from the population employed in industry and from that employed by the government (which will be explained later), we will have to reduce the total transfer payments to the unemployed by the population employed in agriculture from the figure given earlier (9.84) to 1.97 baht per person per year. Given the population in the agricultural sector, this amounts to a transfer of 16,500,000 baht per year from the agricultural sector to the unemployed, or 208 baht for each person in the family of the unemployed worker.

Since we have assumed that disposable income equals expenditure, the additional amount (9.84-1.97 baht per person per year) is assumed to be devoted to consumption, and in particular to consumption of agricultural goods. The reason for assuming that it is devoted to the consumption of agricultural goods is that at least one of the three other items within the category of gifts and contributions, "food and offerings to priests," does remain within the agricultural sector.

There is no reason to question the accuracy of the amount of gifts and contributions reported by the population in the agricultural sector, so while accepting the accuracy of this item and all the other expenditure items, we have to admit that there are a substantial number of people within the sector who are substantially unemployed, or "underemployed" to use the common word. The Buddhist priesthood, who would not be considered unemployed even though their "production" is not valued at any price set in the market, numbered 48,687 in 1960.* Adding the priesthood to the census "unemployed" still yields less than 130,000, compared with the minimum 300,000 persons receiving gifts in the amount of 300 baht per person per year. Thus we could estimate that the number of individuals underemployed, in the sense that they receive substantial help from those more fortunate than themselves, in the agricultural sector is at least equal to the number of unemployed counted in the Census and is probably substantially greater.

The other groups whose income we derive are the three (four if the unemployed are counted) occupying the modern sector. According to the data in the Household Expenditure Survey,** the total outlays per family per month in the towns in the Northeast was 1,104.97 baht per month. Changing this to outlays per person per year, we find it equal to 2,457 baht. We assume that this figure is equal to the average per capita income in the modern sector. The average of 2,457 baht per person per year will result if we make the following assumptions: (1) the population supported by employment in industry has a per capita income of 1550 baht per year; (2) the population supported by the government, one of 2460 baht per person per year; (3) that part supported through the ownership of the capital in industry, an income of approximately 472,000,000 baht per year for the entire group; and (4) that of the unemployed, through donations, one of 300 baht per person per year. The derivation of those figures is shown below, but

*[332], Table VI.

**[300], Table 1.0, p. 18.

suffice it to say here that if (1), (2), and (4) are multiplied by the number of individuals in the group (yielding the income of each group as a whole) and these are added to (3) (which is already stated in terms of a group's income), the total income of the population in the modern sector will be obtained. Finally, if total income is divided by total population in the sector, the average income per capita will be 2,457 baht per year.

According to the Household Expenditure Survey, each family in the modern sector paid 13.04 baht per month as taxes, or allowing for the fact that there were on the average 5.4 individuals in the family, 29.0 baht per person per year.* Gifts and contributions to persons amounted to 15.38 baht per family per month,** assumed to be divided among those employed in the traditional sector and those without employment. In the case of the population employed in the traditional sector, allocating the gifts is simple, for we assumed that all were made to the unemployed. In the case of population employed in industry, however, some mechanism must be found for determining what portion of the transfers are to those still employed in the traditional sector and what portion to the unemployed. In formulating the equations that determine these proportions, we assumed that the proportions were dependent upon the relative sizes of the population groups -- those employed in agriculture and those in industry, on the one hand, and those unemployed and those employed in industry, on the other -- and on a ceiling, representing the maximum fraction of the total income which would be transferred under any circumstances. For the transfer payments from those employed in industry to the unemployed (and similarly for those employed by government to the unemployed) the assumption was that the maximum the group as a whole is willing to transfer is 3 percent of its total income, this being five times the amount actually donated in 1960. The actual proportion will vary depending upon the relative sizes of

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*<u>Ibid</u>.

**<u>Ibid</u>., Table 7.0, p. 39.

the populations employed in industry (or by government) and without employment. Given the actual number of individuals in the two population groups (employed in industry and unemployed) in 1960, the fraction of the group's total income transferred to the unemployed is 0.6 percent.

As the total amount of transfers from the population employed in industry (or equivalently employed by government) is determined by the outlays reported in the Household Expenditure Survey and as the portion going to the unemployed has already been set, that portion going to the population employed in the traditional sector must be equal to the difference. Making allowance, again, for the relative number of individuals supported within the modern and traditional sectors, the maximum fraction of the former's income that would be transferred is 1.6 percent. (The similar fraction for the maximum amount to be transferred from the government employees to those in the traditional sector would be equal to 0.7 percent.) In this way, those employed in industry send gifts of 9.65 baht per person per year to the unemployed and 24.55 baht to those in the agricultural sector.

Subtracting taxes and transfer payments from the income of the population employed in industry, we are left with their disposable income, which are assumed to be identical with expenditures on consumer goods. These are equal to 1,486.84 baht per person per year, divided according to the demand equations into expenditures of 477.20 baht on products from the modern sector and 1,009.64 baht on products from the traditional sector. The coefficients from the demand equations that permit equality between expenditure and disposable income in 1960 are equal to 0.458 for agricultural goods and 0.124 for industrial goods. (The coefficients in the demand equations for the population employed in agriculture were 0.440 and 0.127 respectively.) If, using the demand equation, we calculate the fraction of the total expenditures of the population employed in industry spent on industrial goods, we find that it is equal to 27.2 percent. Comparing this with the percentage reported in the Household Expenditure Survey for the equivalent income class, 3000-5999 baht per family per

year,* the percentage is equal to 31.2. The two figures are not in perfect agreement, which leads us to question the wisdom of using the same values for the price and income elasticities in the demand equations for the populations in both the traditional and modern sector.

The same sequence of steps is used in estimating the average wage, total income, taxes, transfers, and finally the disposable income of the population supported by the government. The initial datum is the average wage paid to the employees of industry, stated above. The Household Expenditure Survey** reports the monthly earnings of employees of governmental and semi-governmental agencies and of private firms, the former being 859 baht per employee per month and the latter 540.*** The average government employee thus earns a little over one-and-a-half times as much as the average employee of private industry, or 2460 baht, taking 1550 baht per person per year as the average income of the population supported by industry. As the total population supported by the government is 237,807, the total yearly income of government employees and their families is equal to 585,000,000 baht. This represents one-and-a-quarter times the income of the group of industrial employees and one-sixth that of the population in the traditional sector. Government activities are, therefore, second only to agriculture in income generated in the Northeast.

If it is assumed that the governmental employees pay the same taxes as those in industry, that is, 13.04 baht per family per month, and that they give to those in the traditional sector and to the unemployed the same amount per person, 15.38 baht, then their expenditures on agricultural and industrial goods are 2,396.84 baht per person per year. According to the demand equations, these would be divided among agricultural and industrial goods in the proportions of 66.2 and

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*[330], Table 1.0, p. 18, repeated in our Table 9.

**<u>Ibid</u>., Table 18, p. 69.

***The former represented 22.9 percent and the latter 19.3 percent of the participants in the survey [330, Table 17, p. 67], approximately 300 observations in all, enough to permit some confidence in the results.

33.8 percent, respectively. The group in the Household Expenditures Survey in the income class within which governmental employees would fall spends 65.2 and 34.8 percent respectively (see Table 10). The various coefficients in the equations describing transfer payments and product demands that yield these data are as follows. The coefficient in the equation determining the transfers from employees of the government to the unemployed was set equal to the maximum percentage of the individual income that would be transferred, 3 percent -- identical with that for the industrial employees. The coefficient reflecting the maximum fraction of government employees' income that would be sent back to the villages is equal to 0.7 percent. These yield yearly transfer payments for each person supported by the government of 18.6 baht to the unemployed and 15.6 baht to the agricultural sector. Since we have assumed that the price and income elasticities are the same for all groups, the only coefficients in the demand equations to be deduced were the constant terms; those in the government employees' demand for agricultural goods equalled 0.468, and for industrial goods, 0.124.

We have assumed that total receipts of the unemployed average 300 baht per person per year. Since the equations have already been formulated in terms of the amounts given, they need merely to be translated in terms of the amounts received; for each person in the group of unemployed this amounts to 37 baht per person per year from the industrial employees, 55 from government employees, and 208 from those in the traditional sector. (All of the transfers from one group to another are displayed in Fig. 11, which shows that the largest single transfer comes from outside the region.) The coefficients in the demand equations for the unemployed are 0.124 for industrial goods (assumed to be identical for all groups in the modern sector) and 0.420 for agricultural goods.

The final group whose income must be estimated is that of the owners of the assets in industry. The method used to determine the income of this group is quite simple but also quite crude, yielding a result in whose absolute value we can place little confidence but in whose changes we may find something of interest. The income of the

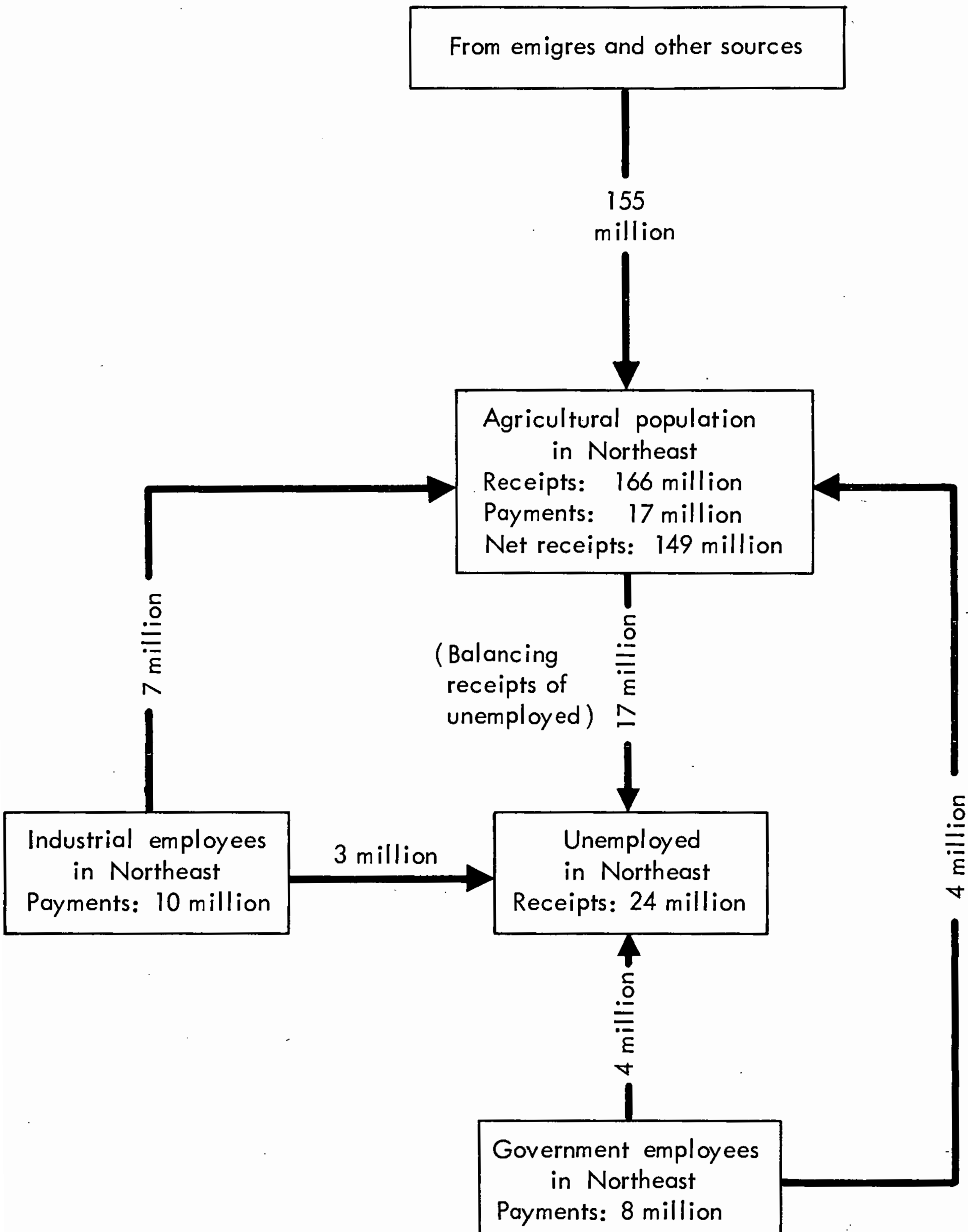

Fig. 11—Transfer payments affecting the population groups of the Northeast (baht per year)

capitalists is derived from the revenues of the business firms; we assume that these are divided equally, at least initially, among the owners and employees of the firms. Thus, one-half of the business firm's revenues will be allocated to employees' wages and one-half to profits and entrepreneural wages. Knowing already that the total income of the employees of industry is equal to 472,000,000 baht per year, that of the capitalists will be the same.*

The coefficients appearing in the demand equations for the owners of capital goods in industry are equal to 0.124 and 0.509 for industrial and agricultural goods respectively. Finally, by starting with the income of the population employed in industry, the income of the population owning the capital goods is obtained, and by adding the two together, we find the value of the industrial output of the Northeast to be equal to 943,000,000 baht per year.

PRODUCTION IN THE REGION

The dependent variables in the equations measuring the demand of consumers are stated in terms of quantities, not in terms of values, but it is necessary to derive the first from the second. We assume a price of 10 baht per unit of industrial output, which will yield a total quantity produced in the Northeast of 94,300,000 units per year. This price, being arbitrary, has no meaning in itself, but variations in it due to market forces are of interest to us.

The factors that enter into the production of this industrial output are capital equipment and labor. The labor force (employees plus their dependents) engaged in the modern sector has already been estimated at 304,252 persons. The equipment, owned by the capitalists and operated by their employees, we assume to be valued at 2,358,000

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*There are no data on the division of the income of the modern sector into wages and profits for Thailand, but figures for one other underdeveloped country indicate that they are of approximately equal magnitudes. In Chile, for example, in 1942 the total national income was distributed 52 percent to entrepreneurs and capitalists, and 48 percent to employees [375].

baht, this being five times the income of its owners, implying an annual return of 20 percent on their investment. There are no statistics to corroborate this figure, so we must not draw any inferences from its absolute value, only from its changes.

The production function used here is not stated in terms of the total employment and total capital of the modern sector but in terms of the capital and employment of each single firm, then multiplied by the total number of firms. We have assumed the number of firms to be equal to 9847, equal to the number of employers and their dependents listed in the 1960 Census. Each firm is assumed to have equal capital and an equal number of employees, so the initial amount of capital available to each firm is 240,000 baht, or 12,000 U.S. dollars, and those supported through employment in each firm will be approximately 31 persons (employees plus their dependents).

Along with estimates of the capital equipment per firm and employment per firm, estimates of the elasticities of substitution in the production function are also needed. Having assumed that the two factors of production share equally the income derived from the sale of their products, we also assume that they are substitutable on an equal basis; in other words, that the exponent of each term in the production function is 0.5. Thus in Eq. (32) in the model, ØFIC1 and ØFIC2 will both be equal to 0.5. If we assume also that in 1960 the system was in equilibrium, with each firm producing at minimum average cost, the value of ØFI will be equal to unity and the constant term in Eq. (32), ØFIC3, to 2720. As estimates of the two parameters measuring technological progress, we assume an annual rate of increase of 2 percent in the maximum attainable output, and an annual rate of increase of 1 percent in the quantities of the inputs necessary to obtain minimum average costs. These parameters can be interpreted as follows: through technological progress, which occurs automatically with the passage of time, the maximum obtainable output of any single firm with a given amount of inputs will rise at a rate of 2 percent per year. Also, improvements in techniques will produce the result that the physical quantities of inputs (which, when combined yield

minimum average cost per unit), will increase at the rate of 1 percent per year. The output yielded by these ever increasing amounts of inputs rises at an annual rate greater than 1 percent per year (the rate at which the inputs increase) and less than 3 percent per year (the sum of the rates of increase of inputs and of maximum obtainable outputs).

The production function for the sector as a whole is obtained by multiplying the production function for the single firm by the number of firms in existence. Given the output for the modern sector in units per year, the number of firms, the value of ØFI (equal to unity if the firms are operating at minimum average cost), and the values of the coefficients of technological progress already assumed, we can derive the value of the final coefficient (CØIC1) in Eq. (31) for the production function, which becomes equal to 9578.

Industrially, the Northeast of Thailand is a deficit region, producing only a fraction of the industrial goods required by its residents. The majority of the industrial goods consumed in the Northeast are manufactured in and around Bangkok or imported from abroad, and are purchased, at least in part, with the funds obtained through the export of agricultural products. In 1962, according to the figures derived from the Household Expenditures Survey, purchases of industrial goods in the Northeast were equal to 2,689,000,000 baht (see Table 12). Our estimate for the value of the industrial output in the Northeast itself was equal to 943,000,000 baht, or 28.5 percent of the total. The remainder, 71.5 percent of the industrial goods consumed in the Northeast, would have had to be imported into the region. The fraction of goods produced in the region is measured by the constant FIØNC1 in Eq. (29). As the development of the Northeast continues, we might expect a greater portion of goods to be produced locally, and therefore the variable FIØN in Eq. (29) to increase through time. We will simulate the model with various values of the coefficient FIØNC2 in Eq. (29), some of which will permit an increase of the proportion of local supply.

Our estimation of output in the agricultural sector follows somewhat the same procedure as that in the industrial sector and uses the same factors of production. But whereas in the industrial sector the estimation of capital was simple and the estimation of output complex, in the agricultural sector the pattern is reversed.

The value of the agricultural output is assumed to be equal to the average per capita income, less transfers received, of the population employed in agriculture, multiplied by the number of persons. Allocating the total value of agricultural output to those living in the traditional sector is justified because the land in the Northeast is owned by those who cultivate it. The returns from the land are inseparable from the returns to the labor applied on it and are reported jointly, for example, in the Household Expenditure Survey. As the average per capita annual wage in agriculture was 806.91 baht per year and as the number of individuals in the traditional sector was 8,390,035, the value of the agricultural output in 1960 was equal to 6,770,000,000 baht per year.

Once again, any price assigned to such a heterogeneous product as agricultural output is arbitrary. We take as most appropriate the retail price of rice in the Northeast, approximately 875 baht per ton.* This yields a volume of agricultural output in 1960 of 7,737,000 tons of rice-equivalent per year, and it is this figure which must be obtained by the proper selection of the constants in the production function for agriculture.

Whereas the production function for the industrial sector permits factor substitution, the production function for the agricultural sector does not, the limiting factor being arable land. Output in the agricultural sector, given fixed technical coefficients and the relative abundance of labor, is therefore equal to the amount of land under cultivation multiplied by the output: land ratio, Eq. (9) in the model. First to be estimated is the amount of land under cultivation, which according to Eq. (8) in the model is an ever-increasing

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*[119, p. 3].

fraction of the total amount of tillable land in the Northeast. This is thought to be equal to 120,000,000 rai, of which about 70,000,000 rai are already under cultivation.* In Eq. (8) in the model, therefore, KUA is equal to 70 million and KLB + CIGA to 120 million. From these two numbers we can deduce KUAC1 to be 0.7143.

In order to estimate the value of KUAC2 (the annual rate at which the remaining stock of tillable land is brought under cultivation), we use some figures from the National Economic Plan, which states that an additional 30 million rai could be brought under cultivation in the next 20 years.** For KUA in Eq. (8) to rise from 70 million to 100 million in 20 years, the value for the coefficient KUAC2 would have to be 0.04186. Thus, if the data are accurate and the prediction materializes, approximately 4 percent of the tillable land still uncultivated will be brought under cultivation each year.

The amount of land that has been brought under cultivation will, following the assumption of fixed coefficients in the production function, support families in proportion to its absolute amount. In other words, if the amount of land under cultivation were to increase by 4 percent in one year, then the number of people it supported would also increase at 4 percent per year. It is this relationship in the model that determines the number of people supported in the agricultural sector.

But output per person, as well as per rai, may increase through time as a consequence of technological progress in agriculture. This is reflected in Eq. (8) by steadily increasing values of the output: land ratio, CØAS. In 1960 this was equal to 0.111 tons of rice-equivalent per rai; in succeeding years we shall assume that it increases at the rate of 1 percent per year,*** (that is, CØASC2 equals 0.01).

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*[327, p. 4].

**[327].

***There are no estimations of the annual rate of technological progress in Thai agriculture that the author could discover, but those

Once again, in order to check the plausibility of our production and demand estimates, we can compare the production of agricultural goods with their consumption. According to our figures, there are 7,737,000 tons of rice-equivalent valued at 6,770,000,000 baht produced in the Northeast each year. Agricultural goods to the value of 5,722,000,000 baht per year are consumed by the population groups living in the Northeast. We assume the balance to be exported outside the region, to finance the Northeast's imports. Of the billion baht per year of agricultural products exported by the region, some is represented by rice, which is exported from Thailand, or which in the other regions of the country displaces other rice that can be exported. The government purchases this rice at the domestic price of 875 baht per ton and sells it abroad at an average price of 1460 baht per ton, retaining the difference as an export tax, the so-called "rice premium."*

We have some figures with which to check the exports of agricultural produce from the Northeast. Output of rice alone in the Northeast varies between approximately 2.5 and 3.0 million tons per year,** which could contribute one-third to one-half of the total value of output of the traditional sector, according to our calculation. Exports of rice from the Northeast are thought to be between 0.5 and 0.8 million metric tons per year;*** assuming an average price of 875 baht per ton and an average export of 0.6 million tons per year, this represents a value of 525,000,000 baht per year. This value for the exports of rice alone compares with ours of approximately one billion baht per year for the exports of all agricultural goods; if our estimates of total exports from the region are accurate, rice itself would

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derived for the United States (1.1%), Germany (1.5%), Great Britain (0.3%), and France (1.1%) during the period 1870-1914, and for Norway (1.8%) during the period 1900-1955 yield such an average [455], as does one estimate of Japan's during the period 1873-1922 [473]. (The other estimate of Japan's is 2.4% [474], and the two have yet to be reconciled [475]).

*[119, p. 5].

**[Ibid., p. 8].

***[Ibid., p. 9].

then contribute 50 percent of the total. Granting that the Northeast does export quantities of maize, pigs and cattle, raw silk and kenaf to the rest of Thailand, and to a much lesser extent abroad, our estimates of the value of exports from the region seem reasonable.

Just as there are production functions for the agricultural and industrial sectors, relating inputs to outputs, so there is a "production function" for government as well. We identify only two portions of its total output: investments in agricultural land and in industrial capital. As we assumed both of these investments to be ultimately appropriated by the respective population groups, the income generated from these investments need not concern us. It is only the act of investment itself that we shall observe. In 1960, total government capital expenditures in the Northeast were equal to 88,391,000 baht* (see Table 13). In the source these are not broken down by sector, but we assume that the fraction in the Northeast is equal to that for the country as a whole. During the three years 1961-1963, 52 percent of the government's capital expenditures were to be made in agriculture and the remaining 48 percent in industry.** Applying these percentages, we estimate that government investment in agriculture in the Northeast in 1960 was 45,900,000 baht and in industry 42,500,000 baht.

The rest of the output of the government is in services, such as protection, education, welfare, and administration. We have not identified these revenues separately: our production function for government, therefore, is unspecified. The major input, civil servants, is assumed to be adequate in number and skills to achieve the output. Any capital goods that have to be imported into Thailand are assumed to be readily available, and to be financed out of the export tax on rice. The rest of the expenditures are assumed to be adequately financed by domestic taxes falling on the different population groups, by foreign aid, and by borrowing, should there be a budget deficit.

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*[327].

**[327, Appendix Table III, "Total Development Plan Expenditure, 1961-1963"].

Table 13

BUDGET EXPENDITURES OF THE THAI GOVERNMENT, BY REGIONS,

FISCAL YEARS 1965 AND 1960

Region	Population (estimate)	Percent of Total Population	Capital Exp. (1000 ฿)	Percentage Distribution	Per Capita (฿)	Other Exp. (1000 ฿)	Percentage Distribution	Per Capita (฿)
1965								
Northern	6,800,100	22.1	430,940	17.47	63.37	220,320	7.65	32.30
Northeastern	10,372,000	33.8	571,386	23.17	55.09	286,409.9	9.96	27.62
Central	9,730,400	31.7	1,124,306	45.59	115.54	2,200,770.5	76.50	226.10
Southern	3,830,600	12.4	339,548	13.77	88.64	169,421.9	5.89	44.92
Total	30,733,100	100.0	2,466,180	100.00	80.25	2,876,922.3	100.00	93.61
1960								
Northern	5,723,106	21.8	265,135.9	30.65	46.32	142,096.3	11.06	24.83
Northeastern	8,991,543	34.2	88,391.9	10.22	9.83	174,451.6	13.58	19.96
Central	8,271,302	31.5	423,537.4	48.97	51.20	895,431.7	69.70	108.26
Southern	3,271,965	12.5	87,906.4	10.16	28.86	72,802.9	5.66	22.25
Total	26,257,916	100.0	864,971.6	100.00	32.56	1,284,782.5	100.00	48.93

Source: [372].

In the case of government income and expenditures, there is no reason why they should be in balance, for the country as a whole, or for the Northeast as a region. According to our figures, it appears that the government budget for the Northeast is in deficit; expenditures in the region amounted to 691 million baht in 1960, covered only partly by revenues of 494 million baht, although revenues are understated by the amount of indirect taxes paid by Northeasterners. The major expenditure was salaries to civil servants. Major revenue came from the "rice premium" (351 million baht per year) and foreign aid (300 million baht total in 1961* which, assuming it was divided on the basis of population, would be 100 million for the Northeast).

We have already compared the output of agricultural goods with their consumption, and the output of industrial goods with their consumption, finding a surplus in the production of agricultural goods over their consumption of 1,048 million baht per year and a deficit in the production of industrial goods over their consumption of 1,746 million baht, the one tending to offset the other (see Tables 11 and 12).

Besides the cash income from exports of regional agricultural goods and the cash that flows out to pay for the imports of industrial products, there are several other cash flows in and out of the region. Taxes equal to 43 million baht per year flow out and funds dispersed by the government in wages to its employees flow in. Government investments in land and industry, as well as private gifts to those in the villages, also flow in. Considering all movements of money, there was an outflow of 1,789 million baht and an inflow of 1,876 million baht. These are illustrated in Fig. 12. The difference, necessary to establish an equality of income and outgo is equal to 87 million baht, about 5 percent of the flow in either direction. The balancing item could be attributed to errors in the estimates, or, if the estimates were correct, to withdrawals of private capital or other unidentified outflows.

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*[128, Table 5, p. 31].

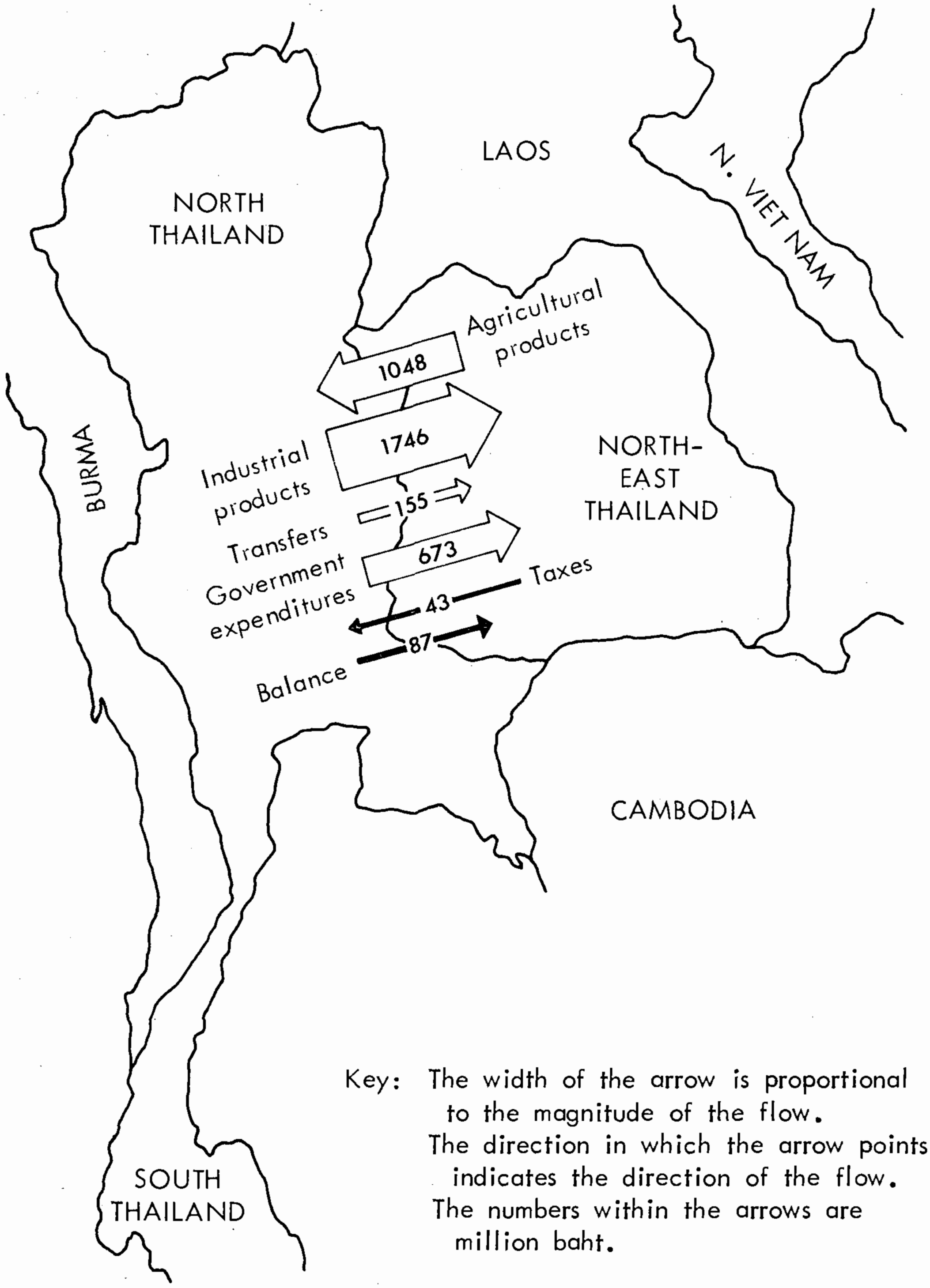

Fig. 12—The Northeast's balance of payments in 1960
(millions of baht)

Factors tending to promote balance are prices, wages, the employment of factors of production, and the output of goods. Although in the model the price of agricultural products is fixed, reflecting the government's entry into the market as marginal buyer, that of industrial products is variable, rising or falling as demands of the consumers or the costs of producers rise and fall, in such a way as to clear the market. Wages rise or fall too, depending on the same phenomena, as reflected most directly in the demand for labor. The assumption of profit maximization guarantees that the wage rate is equal to the value of the marginal product of labor; and this is related to the amount of labor procured through the supply schedule. With the fraction of the available labor supply actually employed equal to 0.79 in 1960, the going wage in industry was 1.92 times that in agriculture;* if the fraction of those available for jobs in industry who were actually employed were higher, we should expect the differential between the wage in industry and that in agriculture to be still higher; if less, to be lower.

The income of the population employed in agriculture is less variable, being tied, in our model, to agricultural output, which in turn is tied to the amount of land under cultivation. The income of the government employees is completely arbitrary, with both the number of civil servants and their annual wages being considered to be policy instruments. All other government policies -- the various taxes that are collected and the expenditures that are made -- are also arbitrary. Summarizing their methods of determination, taxes have been related to the number of individuals within each population group. Government investment in land and in industry is arbitrary. Allowance has been made for investment by the owners of firms, assuming that one-half their expenditures for industrial goods represents additions to their capital. The depreciation rate was initially set at a value (4.59 percent per year) such that total depreciation was equal to private net

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*For unskilled labor in 1966, the going wage in industry was 1.5 times that in agriculture: a laborer in Bangkok received 15 baht per day, while the wage paid to village labor on government development projects was 10 baht per day [377].

investment in industry. Government investment in industry, at the rate at which it was being made in 1960, would yield a net growth in the capital stock of 2 percent per year.

In the model we have allowed for the fact that the government could stimulate the formation of new firms, and also that the government could institute family planning, although in 1960 there was no evidence that the latter of these two policy instruments was being used.*

CONCLUSION

This completes the picture of the economy of the Northeast of Thailand in 1960. It has been built up of the structural relationships formulated in Sections III-VII, several assumptions, and many statistics. Most of the magnitudes seem to be plausible, although some -- such as the number of industrial firms, the elasticities of factor substitution, the incomes of the owners of capital goods, and the investment rates in industry -- may be greatly in error.

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*[451].

IX. THE GENERAL BEHAVIOR OF THE MODEL

We cannot tell in advance whether our model of the economy of the Northeast simulates actual future events, but we can test whether or not we have devised a model that will exhibit some regular pattern of behavior. After simulating the economy, we did find it to behave in generally the same fashion, regardless of the stimuli. This section attempts to illustrate the pattern by describing a typical case. It is hoped that the example will reveal the general properties of the system and offer a basis against which the effects of changes in the inputs or in the structure of the system can be determined.

There are three reasons for choosing a particular case as a basis for comparison: (1) the structure of the model which underlines it is the one described in Sections III to VII; (2) the values of the parameters are the ones that seem most realistic, having already been described in Section VIII; and (3) it is as simple as possible, in that all the exogenous rates of growth are constant.

The point of departure for the simulation is the economy of the Northeast as it existed in 1960. To generate growth it is necessary to propel the economy forward in time, causing certain portions of the model to grow spontaneously and letting the remainder respond to this growth. Certain elements of the economy -- for example, population, number of firms, and productivity -- do increase in reality and thus must do so in our model. The most important rate of growth is that of the population. In our example, we assume that the population grows steadily throughout the simulation at the rate of 3 percent per year.

The 4 percent rate at which the existing stock of arable land is brought under cultivation is slightly larger than the population growth rate. This percentage was presented in Section VIII and derived from the Thai government's estimate of the likely increase in cultivation under the National Economic Development Plan. We maintain the assumption that, in agriculture, land and labor are combined in fixed proportions, but, following the reasoning in the

preceding section, that productivity increases at the rate of 1 percent per year. In this way the output of the agricultural sector will show a dual increase, first, through the increase in the amount of land under cultivation and, second, through the increase in the efficiency with which the land is farmed.

In private industry, technological progress is assumed to take two forms: increases in the maximum output that can be obtained from any given amount of inputs, and extensions in the range over which economies of scale operate. For this example we assume that the rate of increase of maximum output from given inputs is 2 percent per year, and that the extensions in the range over which economies of scale operate is 1 percent per year. The values of the coefficients in the production function for the modern sector have been set so that the actual number of firms, the number of employees of industry, and industrial capital investment as of 1960 are of such magnitudes that resources are being used most efficiently; in other words, so that each firm is operating at minimum average cost.

Consumers are assumed not to alter their general behavior, continuing to divide their expenditures among agricultural and industrial goods on the same basis as in the initial year (1960), and, in the case of the wealthier groups, to support the unemployed and the government. Price and income elasticities are kept the same as in 1962, the year in which the household budget study was conducted, all groups having price elasticities of demand for agricultural and industrial goods of -0.8 and -1.2 respectively, and income elasticities of 0.9 and 1.1. Under the assumption of homogeneous demand equations, the cross-elasticities for agricultural and industrial goods are equal to -0.1 and 0.1, respectively. Half of the expenditures of the entrepreneurs on industrial goods are assumed to be in the form of capital investment in their firms, the other half in the form of consumption.

In the model, three mechanisms tend to promote balance between the activities in the different sectors: prices of industrial goods, wages of industrial labor, and employment. The agricultural sector operates quite smoothly, for the price of agricultural goods is held

constant and output rises mildly and regularly as new land is brought under cultivation and new techniques are adopted. The price of industrial goods is free to vary, in response to changes in demand; the wage paid to labor in industry is also free to vary in response to the amount of laborers seeking work and to the profitability of manufacture. A minimum is set, equal to the wage in agriculture plus a slight differential, below which wages in industry will not drop even though unemployment may be high. This minimum rises through time, following the rise in the average wage in agriculture.

It has already been mentioned that the government may encourage the formation of new firms: we assume that this will occur to such an extent that each year the total number in existence increases by 5 percent. There are a number of other assumptions: (1) that the government will increase the number of civil servants by 10 percent annually in order to carry out an ambitious investment program and extend its regular activities within the region; (2) that the wages of civil servants will rise at a rate of 3 percent per year; and (3) that the government will not try to influence the rate of growth of the population in any way, and therefore will not allocate funds to family planning. The expenditures by the government in the field of investment are divided between agriculture and industry in the same amounts as were budgeted for 1965, and are assumed to increase at equal rates of 10 percent per year.

Since the model is very complex it does not reveal its general behavior via the movement of any single variable, but by the often diverse movements of many variables. To see what the general characteristics of the system are, we must describe the movements of several different component parts.

Of greatest importance are the trends in employment and unemployment. Although the total population grows at a rate of 3 percent per year, the portion employed in agriculture grows at only a little more than half that rate (see Fig. 13). The remainder can find work only in the modern sector. Since the portion of the total population supported in the modern sector is only 7 percent at the outset, the

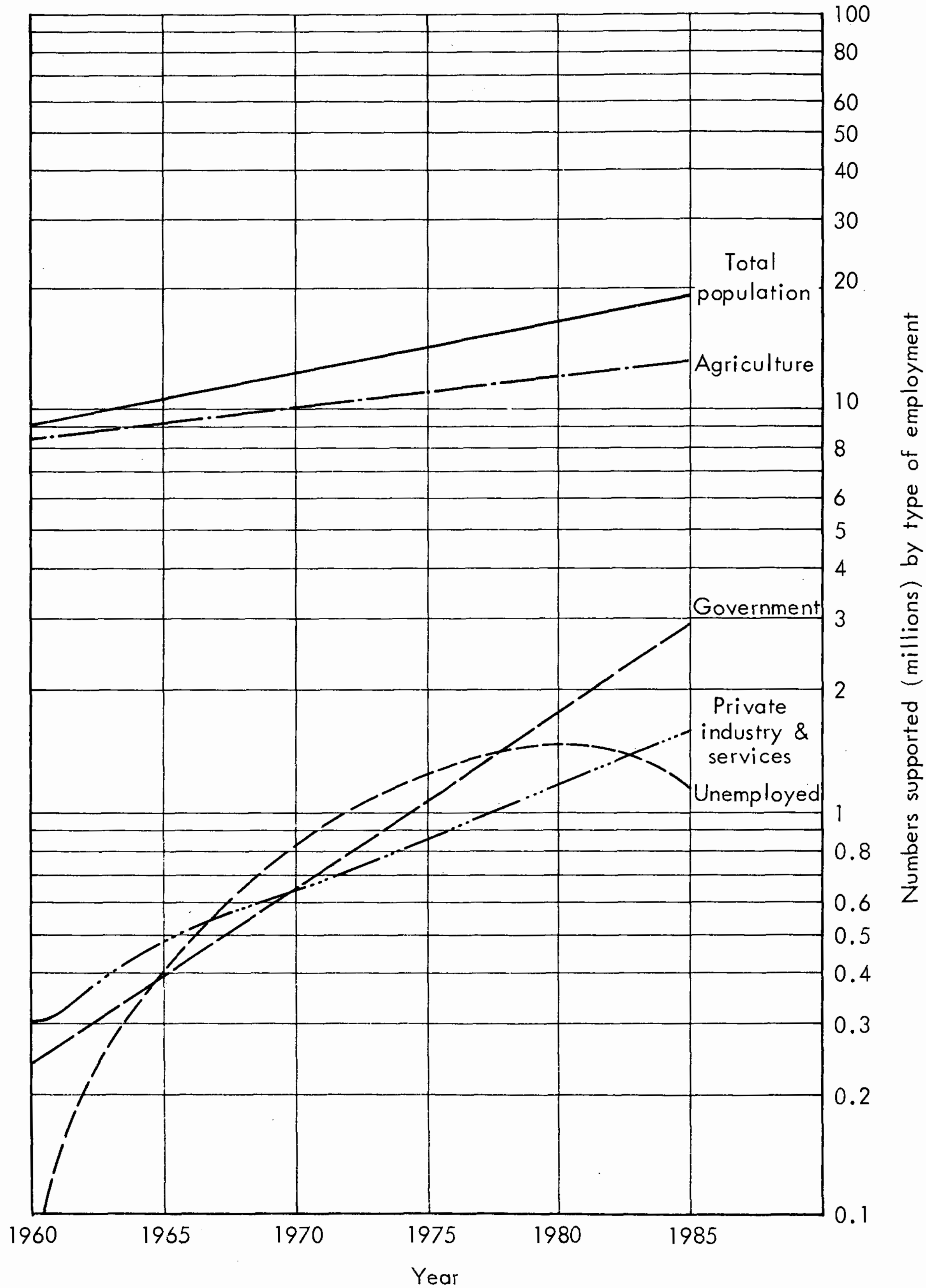

Fig. 13—Distribution of the population of the Northeast by type of employment, 1960-1985 (base case)

annual surplus from the traditional sector represents, in the first year, an increase of approximately one-fifth in the urban labor force. In succeeding years, provided the industrial base grows faster than the population at large, the annual surplus will diminish proportionately; nevertheless, the part of the population seeking employment in the modern sector will still grow at a far greater rate than that of the population as a whole.

By assuming that the Thai government increases its employment by 10 percent per year, we make great inroads into this labor pool. The number of civil servants rises from approximately 238,000 in 1960 to 1,176,000 in 1980.

Employment in private firms in the modern sector, determined not by government policy but by the profitability of manufacture and competition with imports, grows steadily from 1960 until the end of the simulation. Employment in private industry rises from 304,000 in 1960 to 1,175,000 in 1980, the rate of increase being approximately 6 percent per year.

Even with the rapid rise in government and private employment in the modern sector, not all of the available workers find jobs. From approximately 80,000 (individuals plus their dependents) in 1960, the number of unemployed rises rapidly. By 1980, when the peak is reached, there are 1,440,000 (individuals plus their dependents) unemployed -- that is, 55 percent of the industrial labor force and 8.7 percent of the total population. Only after 1977 does unemployment drop in proportional terms and after 1980 in absolute terms.

The trends in real incomes are similar to those in employment. Incomes of the groups supported by agriculture and by the government are assumed to rise steadily (see Fig. 14). The incomes of those employed by private firms in the modern sector varies, for they are subject to two conflicting forces, first one and then the other of which dominates. With increasingly high percentages of unemployment, income per capita tends to fall; with increases in agricultural income, below which industrial wages cannot fall, income tends to rise. The

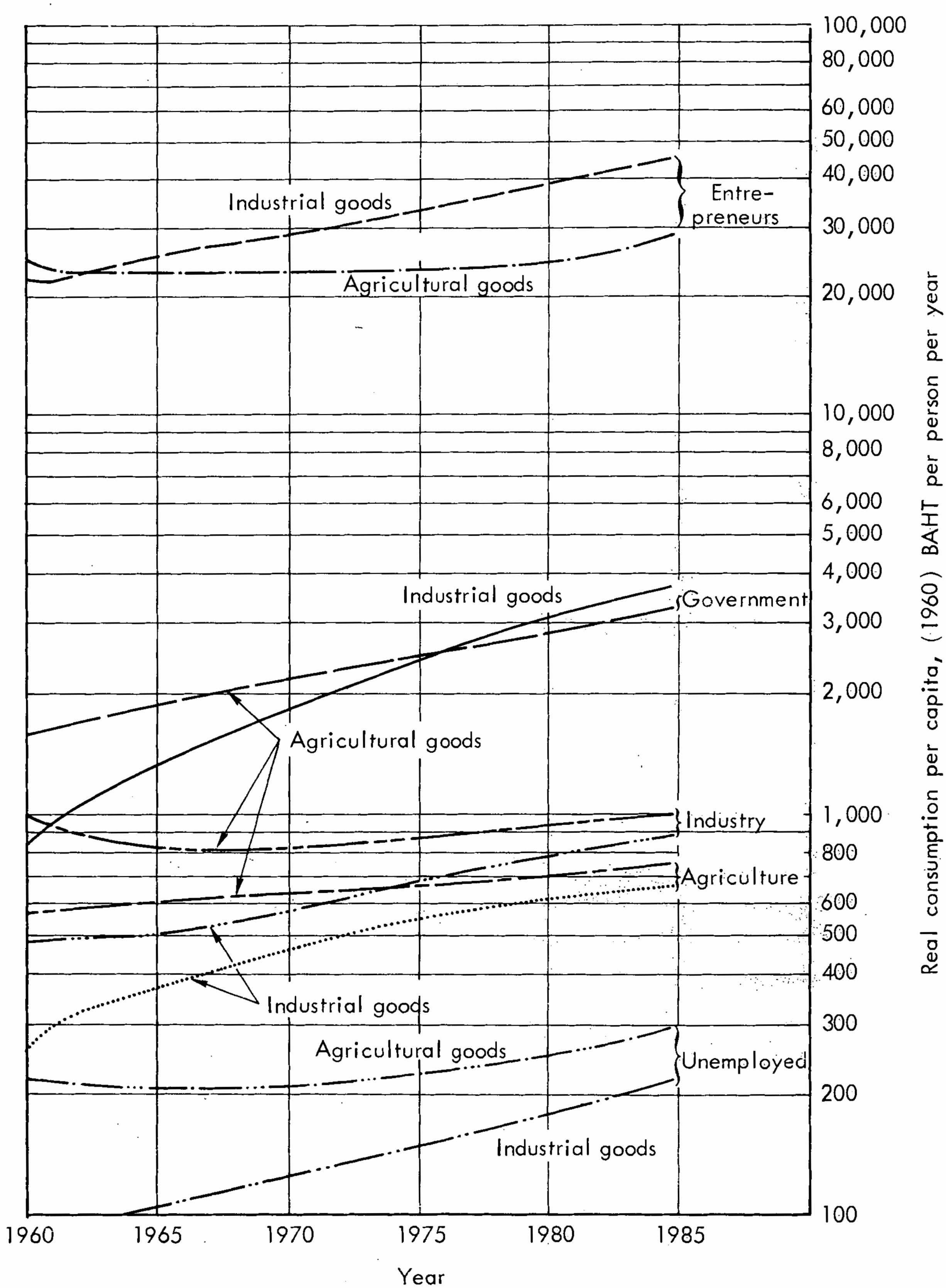

Fig. 14—Variations in consumption in the Northeast for individuals in different types of employment, 1960-1985 (base case)

result is that at first, in the period 1960 to 1965, real income per capita for those employed in industry falls; after 1965, it rises. By 1974 real income has recovered its initial value and by 1980 it has exceeded the initial value by 13 percent.

Transfer payments to the unemployed, in the form of gifts from the employed, follow a different pattern from industrial wages, rising throughout, very slowly at first and more rapidly toward the end of the simulation. If the relationships formulated are realistic, the unemployed will receive enough to subsist upon, in spite of the increase in their numbers. Idleness rather than poverty will be the problem.

The final group in the population, those who receive income from the ownership and administration of private firms, continues to do well. Unemployment produces pressure upon wages, so that the costs of manufacturing industrial goods fall in greater proportion than the price of the goods. Consequently, the residual left after wages are paid, constituting the income of this group, steadily rises.

Throughout the simulation, the changes in the distribution of income per capita among the different occupational groups are relatively slight. At first, those who are employed in industry suffer a decline relative to the rest, but after 1967, the distribution remains relatively stable (see Fig. 14). The distribution of the total income of the Northeast among the various classes does change substantially, however, because of their different growth rates (see Table 14). The five-fold rise in the number of civil servants produces an equivalent rise in their share of total income; the nearly twenty-fold rise in the number of unemployed produces a seven-fold share rise.

Looking at private firms in the modern sector, their stock of capital goods rises faster than employment. By 1980 the capital invested has increased from 2.3 to 11.4 billion baht, a yearly increase of 8 percent, whereas employment has risen at a yearly rate of approximately 6 percent. The number of firms that employ these resources rises also, at the rate of 5 percent per year (arbitrarily set at the

Table 14

DISTRIBUTION OF POPULATION AND INCOMES BY OCCUPATIONAL GROUP, BASE CASE, 1960 AND 1980

Occupation	Population				Real Income[a]			
	Number (000)		Fraction of Total		Per Capita		Fraction of Total	
	1960	1980	1960	1980	1960	1980	1960	1980
Traditional Sector:								
Employed in agriculture	8,390	12,044	0.930	0.733	823	1,316	0.820	0.516
Modern Sector:								
Employed in private firms	304	1,175	0.034	0.071	1,487	1,689	0.054	0.065
Employed by government	238	1,757	0.026	0.107	2,397	5,998	0.068	0.343
Owners of private firms	10	27	0.001	0.002	46,838	64,210	0.055	0.055
Unemployed	79	1,436	0.009	0.087	300	423	0.003	0.020
Totals	9,021	16,438	1.00	1.00	933	1,866	1.00	1.00

Note:

[a]Real income equals consumption at 1960 prices and includes, for the portion of the population owning and managing private firms, their gross investment. Income of the unemployed is derived of gifts from the first three groups.

beginning of the simulation). Since employment and capital rise faster than the number of firms, each firm grows in size. The growth in the size of firms is even greater than the rate at which economies of scale are extended, with the result that each firm increasingly operates at a level of output greater than that at which minimum cost is obtained. By 1980, the range over which economies of scale can be obtained is increased by 20 percent, whereas the amount of resources controlled by each firm is increased by 60 percent. If we use the ratio ØFI in Eq. (31) as a measure of the efficiency with which resources are used in production, the most efficient combination would yield a value of unity; less efficient combinations would yield ratios at variance from unity, greater or less. In 1980, with the numerator 1.20 and the denominator 1.59, the measure of efficiency, ØFI, is 0.76.

Another measure of efficiency for the economy of the Northeast as a whole is the real output of agriculture and industry per inhabitant of the Northeast (ROPC). This rises from 748 baht per person per year in 1960 to 1,019 in 1980. The increase is made up of a steady rise of 1 percent per year in the output of the traditional sector, and a less steady increase of approximately 3 percent per year in the output of the modern sector. The increase in output per capita in agriculture comes about solely through technological improvements, whereas that in industry is the combination of four different factors, three yielding an increase in productivity and one a decrease. Two of the three factors raising productivity are the increase in the maximum obtainable output and the increase in the range of economies of scale, which are the results of technological progress. The third factor is the growth of capital equipment, which is the result of investment by entrepreneurs and by the government. The decrease in productivity comes through the less efficient use of resources, as firms produce at levels above that of minimum average cost.

On the whole, consumption rises at approximately the same rate as does output. Since their income elasticity is greater than unity, the consumption of industrial goods rises faster than income, but not

as fast as output. As a consequence, and as a further consequence of the pressure of unemployment on wage rates, the price of industrial goods falls steadily throughout the simulation (see Fig. 15).

The increase in money income and the fall in the price of industrial goods permits more to be spent on agricultural goods. The demand increases faster than the output: by 1970, export of agricultural produce from the Northeast has ceased; after 1970 the Northeast becomes a deficit region, having to import foodstuffs from the rest of Thailand.* No longer is the region producing a surplus, to be exchanged for industrial goods; after 1970 it imports both agricultural and industrial goods, incurring ever larger deficits in its balance of payments.

Since both agricultural and industrial goods are being imported into the region from 1970 onward, the funds to purchase these goods must come from outside. In our model, and probably in reality, the only source is the Thai government. In 1960 it contributed one-sixth of the income in the region, by means of wages paid to civil servants and by investment in agriculture and industry, but by 1980 it contributes nearly half of the total. Out of a total income of the Northeast of 22.5 thousand million baht in 1980, expenditures by the Thai government amount to 10.4 thousand million.

Government expenditures devoted to agriculture were 180 million baht in 1960, and they are assumed to rise at an annual rate of 10 percent to 1.3 thousand million baht in 1980. Expenditures in industry increased at the same rate from 166 million to 1.2 thousand million baht per year. In addition to the 10 percent increase in employment, the average wage of each civil servant is assumed to rise by 3 percent per year. The growth in total wages of all civil servants is therefore 13 percent per year, rising from 585 million baht to 7.9 thousand million baht over the generation.

*News reports of starvation in the Northeast in 1969 [509] suggest that in some provinces at least a net deficit already exists.

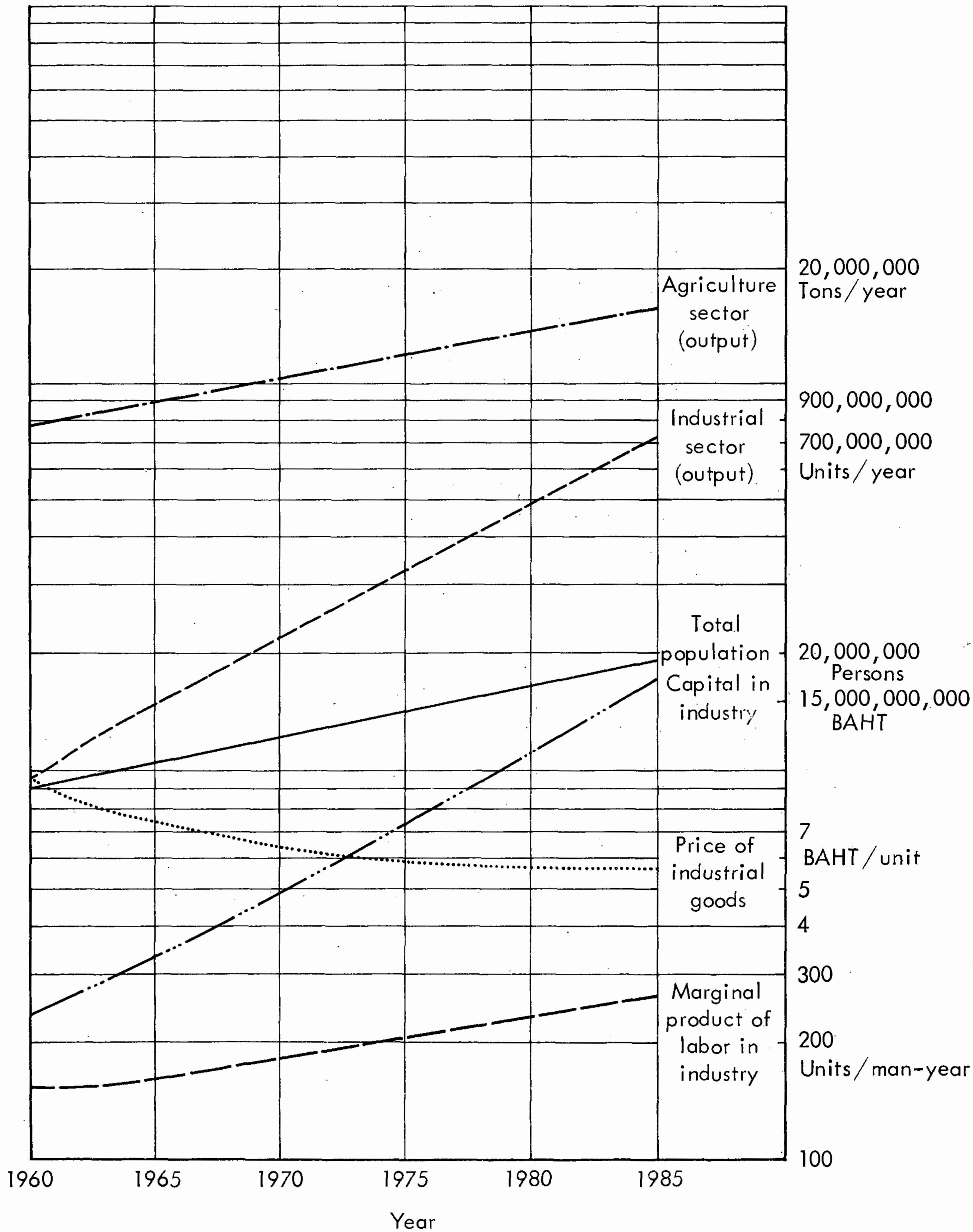

Fig. 15—Growth of output and capital, and variations in productivity and price, in private industry, 1960-1985 (base case)

According to the model, in 1960 the government collects less in revenues from the Northeast than it spends in the region. Neglecting indirect taxes, the budget deficit is 861 million baht. (If we were able to measure indirect taxes, the deficit would be somewhat less.) By 1980, the deficit has risen to 12.7 thousand million baht, a figure even greater than total expenditures. The deficit exceeds expenditures because the Northeast becomes an importer rather than an exporter of food. The Thai government loses not only the "rice premium" on the former surplus from the Northeast, but also the export tax on rice which is displaced from the export market to meet the deficiency in the region.

We may question the plausability of government expenditures of the magnitudes indicated in the model. To be sure, from 1960 to 1965 expenditures have been increasing annually at rates even greater than 10 percent. The absolute amounts, however, have been very small, and it is doubtful that this rate of growth of expenditure could be maintained. An annual rate of growth of 10 percent yields, after 10 years, a figure 2.7 times the initial one; of 20 percent, a figure 7.4 times the initial one. Over a decade or a generation, growth can be a formidable thing indeed, and it certainly is in the model. Government expenditures in the Northeast in 1980 are not only 7.4 times as great as in 1960 but nearly twice total government expenditure in <u>all</u> of Thailand in 1965 (10.4 versus 5.3 thousand million baht).

The other rates of growth -- population, technological progress, land under cultivation, and capital in industry -- are more modest. To reduce unemployment substantially, without increasing government expenditures, it is necessary to assume either a lower rate of growth of the population, which is unlikely, or a greater increase in productivity, which may be unobtainable. Without such increases, the number without regular support in 1980 (1.4 million individuals, or 8.7 percent of the population) is so large as to be surely wasteful and perhaps hazardous.

But these numbers are merely the results of the working out of the model. Had the values of the parameters been changed, the outcome

would have been different. As several of the relations and an equal number of parameter values are questionable, we must try to determine what would be the effects of substituting others. We do this in the next section, when we try to determine the sensitivity of the system.

X. SENSITIVITY OF THE SYSTEM

The results of the simulation in the base case seem, to the author at least, plausible. But plausibility, although necessary, is not sufficient for the acceptance of either the technique of simulation or of the model of the economy of the Northeast of Thailand. Ideally, we should like to compare, with their real values, the paths that the variables in the model pursue through time.

Having simulated the interval from 1960 to 1985, we have, in the first 10 years 1960-1969, the results for a decade nearly past. But the values that the variables measuring output, employment, incomes, and so on, actually took throughout the decade are unknown. The statistical data needed to construct the tableau économique for 1960* are not available for any subsequent year and, unless special surveys are made, will not be available until the mid-1970s. Therefore, only the briefest and roughest comparison of the simulation with experience can be made.

The only statistical data that we have not already used in determining the initial values of the variables and that cover the Northeast separately are the National Accounts, broken down by region for the period 1960-1963 [604]. While the Gross Domestic Product (in current prices) of Thailand as a whole was growing by 23 percent, that of the Northeast was growing by 15 percent, from 10,472 million baht to 12,045 million baht [604, Table 1, p. 39]. If we were to compensate for changing prices by using the implicit GDP deflator [602, Table 8, p. 125: 1960, 93.87; 1962, 100; and 1963, 96.21], we would find that the growth of GDP in the Northeast from 1960 through 1963 was 12 percent.

In the simulated "history" of the base case described in the previous section, over the same period 1960-1963, total income in the Northeast (TC in our nomenclature) in constant prices rose by 13 percent. Although the period of comparison is very short, the real and

*Taken mainly from the Population Census of 1960 [326], the Agricultural Census of 1963 [329], and the Household Budget Study of 1962 [330].

fictitious results are similar. In per capita terms, the comparison between the real and simulated data is equally satisfactory. From 1960 through 1963, real GDP per capita in the Northeast rose 5.2 percent in current prices and 3.0 percent in constant prices. In the simulation, income per capita (TCPC) rose 2.9 percent.

We can extend the comparison to the agricultural sector. Gross Domestic Product of Agriculture grew from 5,506 million baht in 1960 to 6,053 million baht in 1963, an increase of 10 percent [604, Table 1, p. 39]. These figures are in current prices; we do not know their equivalents in fixed prices. Our simulated increase in the output of the traditional sector (ØAS), over the same period and in fixed prices, was 9.1 percent.

But 1960-1963 is a very short period and aggregate output a very limited measure of the overall behavior of the economy of the Northeast. We need more than this modest likeness to accept the model as realistic. To what other tests might we subject it? One question we can ask is whether changing the conditions under which the model is simulated will induce changes that might be expected. The same question can be posed for changes in inputs, in parameter values or in the structure of the model: Are the consequent changes in behavior such that they would conform to economic theory and to our general knowledge of the economy of the Northeast?

Our approach to this problem of sensitivity will be to move from the simplest case to the more complex, ending when we are unable to generalize about the results. The results will be compared against the case described in the last section, called the base case. The first set of cases in this section will test how resilient the system is to random shocks. If displaced from the growth path does it automatically return, or does it thereafter follow a new path?

Shocks can occur sporadically or in a steady stream, and we shall try to determine the effect of each possibility. Examples of sporadic shocks might be an unusually bad or good harvest or an increase or decrease in the industrial wage rate. We shall determine the stability of the system in each of these situations.

TESTS FOR THE RESILIENCY OF THE SYSTEM TO SPORADIC SHOCKS: CASES ∅AS-A THROUGH ∅AS-D

Table 15 summarizes the effects of sudden and prolonged harvest failures. The cases proceed in order of increasing severity: the first alternative (∅AS-A) reflects a 10 percent reduction of agricultural yields in 1970; the second (∅AS-B), a 20 percent reduction; the third (∅AS-C) 30 percent; and the fourth and final (∅AS-D), 50 percent. Following Eq. (5) in the model, the effect of the abrupt reduction is to force a sharp dip in the upward trend of productivity. Yields per rai rise steadily until 1970, fall back very sharply in that year, and then resume a slow but steady rise from the low value suffered in 1970.

Since the price of agricultural products is assumed to be fixed, the immediate consequence of the harvest failure is a fall in agricultural incomes. Farmers' demands for both types of goods, agricultural and industrial, fall too, resulting in a mild reduction in industrial output, a more severe reduction in industrial employment, and a very severe reduction in the price of industrial goods. The absolute price reduction makes these goods cheaper than agricultural goods, which mitigates the income effect, and leads within the next year to the resumption of the growth of industrial output, at an even higher rate than before.* Employment in industry recovers, and within a few years is greater than in the base case; exceeding it in 1980 by 2.1 percent in case ∅AS-A, 4.5 percent in ∅AS-B, 10 percent in ∅AS-C, and 36 percent in ∅AS-D (see Table 17, p. 188). Because we specified in the model that employment in agriculture was dependent upon the quantity of land available rather than upon the income derived from its cultivation, there is no change in agricultural employment from one case to the next.

As the income derived from agriculture drops in 1970, so does the industrial wage, which is tied to agricultural earnings.

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*As a result of the failure of the harvest, there may be some shortage of raw materials for industry, but we have neglected this.

Table 15

CHANGES IN CERTAIN VARIABLES WITH FAILURES OF HARVESTS (AFTER 1970)

Variables		Values				
Definition	Symbol	Base Case	ØAS-A	ØAS-B	ØAS-C	ØAS-D
INPUTS - 1960						
RATES OF GROWTH						
Population	MXRGP					
Decline in R.G.P.	NDRGP					
Cultivation	KUAC 2					
Productivity, ag.	CØAS 2	0.1105	0.1050	0.0995	0.0884	0.0553
Local supply	FIØNC 2					
Productivity, ind.	CØIC 3					
	CØIC 5					
PROPENSITIES						
Est. new firms	NFEKC					
To invest	APIKC					
Price elasticity	PEAAC					
Income elasticity	YEAAC					
GOVERNMENT POLICIES						
Growth of ag. inv.	EGAC					
Initial ag. inv.	EGAC 1					
Growth of ind. inv.	EGKIC					
Initial ind. inv.	EGKIC 1					
Est. new firms	NFEGC					
Growth of civil serv.	INPEG					
Growth of salaries	IWEGC					
Family planning	IDRGIP					
OUTPUTS - 1980						
OCCUPATIONAL GROUPS (000)						
Total population	PT	16438	→			
In agriculture	PEA	12044	→			
In government	PEG	1757	→			
Entrepreneurs	PØKI	27	→			
In industry	PEI	1175	1200	1227	1291	1545
Unemployed	PU	1436	1411	1384	1320	1016
Fraction employed	FAEI	0.45	0.46	0.47	0.49	0.61
PRODUCTION, ETC.						
Ag. output (000)	ØAS	13565	12887	12209	10853	6783
Ind. output (000,000)	ØIS	488	491	494	502	536
Capital stock (000,000)	KI	11364	11320	11277	11189	10427
Efficiency	EFFI	0.755	0.748	0.741	0.725	0.660
Number of firms	NFI	26700	→	→	→	→
Price of ind. goods	DPIØ	5.6	5.4	5.3	4.9	3.8
INCOMES (baht per year)						
In ag., per capita	TCPCA	1316	1276	1236	1152	860
In govt., per capita	TCPCG	5998	6127	6263	6577	7894
Of capital, per capita	TCPCK	64210	64229	64271	64482	66549
In ind., per capita	TCPCI	1689	1639	1541	1492	1163
Unemployed, per capita	TCPCU	423	416	409	396	359
Average per capita	TCPC	1866	1848	1832	1802	1720
Total income (000,000)	TC	30686	30370	30120	29600	28240
Output per capita	RØPC	1019	985	951	883	687
Total output (000,000)	RØ	16750	16186	15627	14518	11244
GOVERNMENT EXPENDITURES						
Total (000,000)	EG	10433	→	→	→	→
Ag. inv. (000,000)	EGA	1330	→	→	→	→
Ind. inv. (000,000)	EGKI	1227	→	→	→	→

Entrepreneurs are encouraged to substitute labor for capital in production, so even though industrial output rises more rapidly than in the base case, investment in industry rises more slowly. Entrepreneurial incomes drop in money terms, but rise slightly in real terms. The real incomes of civil servants, whose money incomes are unchanged, rise substantially with the fall in the price of industrial goods. However, the real incomes of the majority of the population -- those in the traditional sector, those in industry, and the unemployed -- decline relative to the base case; the more severe the harvest failure, the greater their decline.

The decline in the output of agricultural goods is greater than the decline in their consumption, so that the surplus available for export from the region disappears in the year of the failure. The reduction in consumption in the region, relative to that in the base case, is less grave than the reduction in output, due to the (assumed) willingness of the Thai government to maintain the domestic price of rice at what is becoming an increasingly low figure. In contemporary Thailand this permits the government to appropriate the "rice premium"; in our simulated future it permits consumption in the Northeast to exceed production.

In addition to the above case of crop failure, we simulated an equal number of good harvests, with exactly opposite results. Within the range of agricultural yields -- one-half those in the base case to twice those in the base case -- the model exhibited qualitatively similar behavior; neither the most disastrous nor the most abundant harvest produced aberrent results. Other elements built into the system -- the flexibility of prices, wages, employment, and output in the industrial sector, and the readiness of the government to buy the surplus or supply the deficit in the agricultural sector -- acted as buffers.

Subjecting the system to equally severe shocks in the wage mechanism also fails to disrupt it. In one case, we suddenly doubled the differential between the agricultural and the industrial wages necessary to mobilize labor, and in another case trebled it. The immediate

effect of the changes was to shift the entire supply schedule for industrial labor upwards (see Section IV, Fig. 9), thereby hoisting the going wage.

In the first variation, doubling the coefficient WDFC in 1970 had the effect of raising the average wage from 1196 baht to 1461 baht per year; in the second, trebling WDFC had the effect of raising the average wage to 1700 (see the middle plot on Fig. 16, cases WDF-A and WDF-B respectively).

The response of entrepreneurs to higher wages is, as might be expected, a reduction in employment (see the middle plot of Fig. 17), and -- since they are operating at levels of output above minimum average cost -- in output (the upper plot). Price rises, although in lesser proportion than wages, and profits (the bottom plot of Fig. 16) immediately rise, then fall, and subsequently follow nearly the same path as in the base case. The capital invested in industry, being dependent upon the income of entrepreneurs over the long run, varies little from case to case; the difference between the three cases is never more than one percent and their time paths cannot be distinguished separately.

The general response of the system to shocks in industry, therefore, is to dampen them; the more severe the shock, the greater the agitation, and the longer the interval to "recovery." Recovery is defined as the resumption of output and employment growth at the same rate as would have occurred had the shock not been imposed, and of parallel paths for price, wages, and other variables. But the economic losses, measured as the difference between what might have been achieved at any instant and what is being achieved, can be substantial. For example, industrial employment in 1980 in the second alternative case, WDF-B, although growing at the same rate as in the base case, is 325,000 persons less, occupying the level reached in the base case in 1975. Recovery is only partial; losses are irrecoverable.

In industry, after the upward shift in the labor supply schedule, there are fewer workers earning higher wages and the same number of

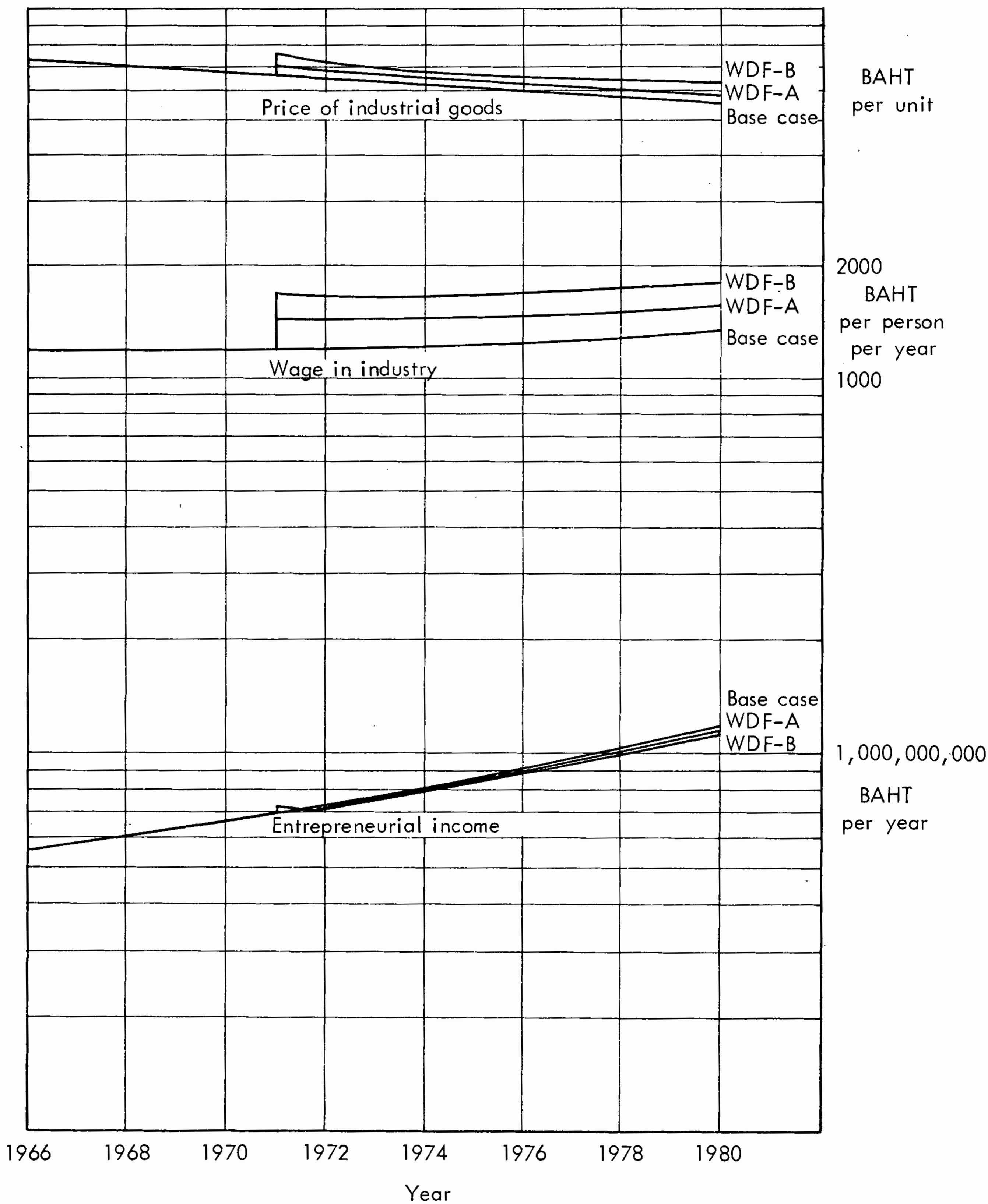

Fig.16 — Growth paths of price, wage rate, and entrepreneurial income in industry following a sudden rise in wage rate (in 1970), 1966 - 1980

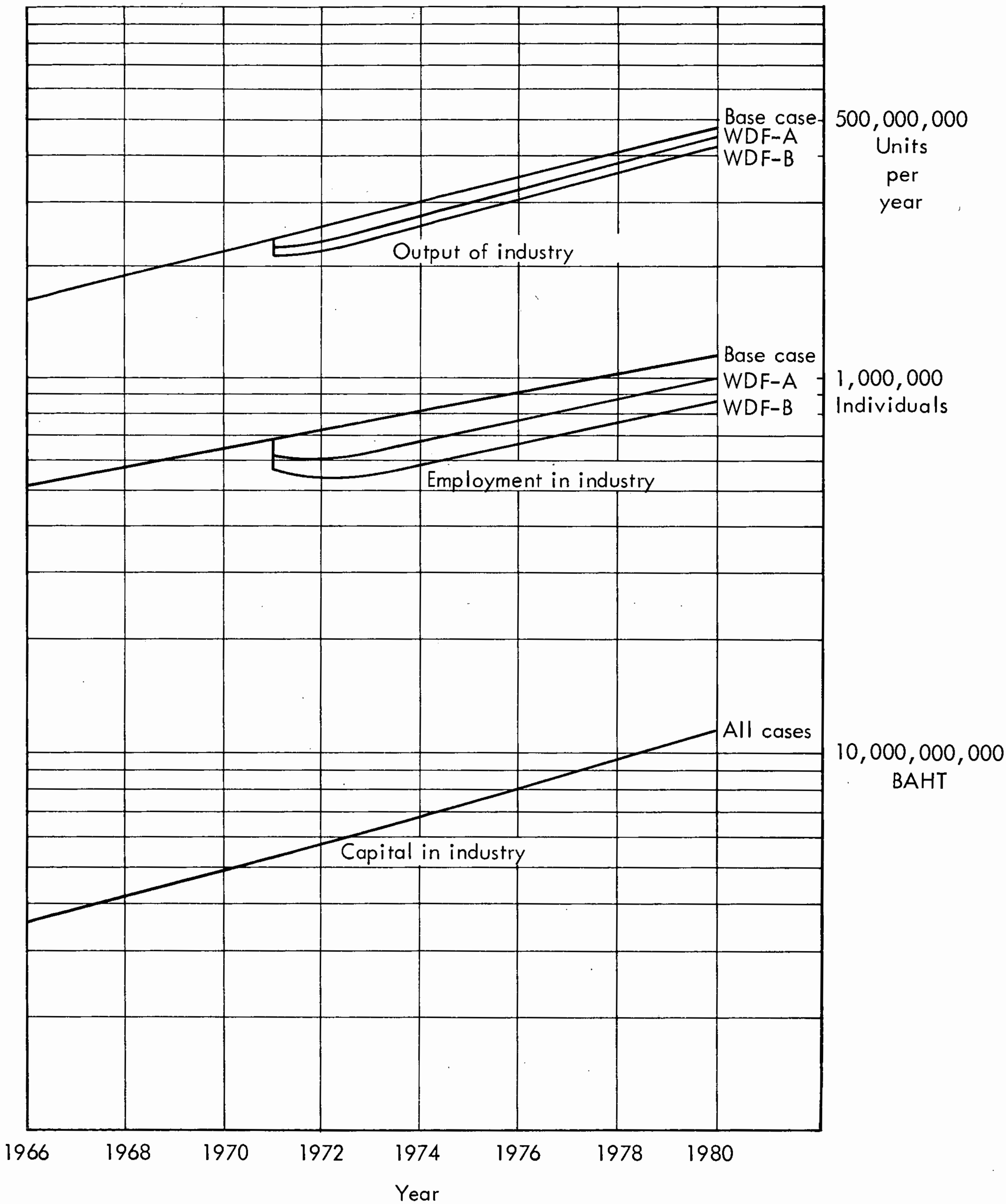

Fig. 17 — Growth paths of output, employment, and capital stock in industry following sudden rise in wage rate (in 1970), 1966 - 1980

entrepreneurs drawing very slightly less profits, so there has been a redistribution of income from capital to labor. With the rise in the price of industrial goods, there is also a redistribution of income from the non-industrial sectors -- agriculture and government -- to industry. The forcing up of industrial wages benefits industrial labor relatively and absolutely, and harms all the other occupation groups in both senses.

TESTS FOR THE RESILIENCY OF THE SYSTEM TO CONTINUOUS SHOCKS

The places to insert continuous shocks are at those points where variations might be expected to occur in the real economy. The most likely points would seem to be in the production functions of agriculture and industry, in the investment decisions of entrepreneurs, in the establishment of new firms, and in the levels of government expenditures. We consider all but the last of these here; variations in government expenditures will be considered in the next section.

The response of the system to continuous shocks is less interesting than its response to sporadic shocks. With fluctuations in agricultural output, there are fractional fluctuations in agricultural income, in the demands for both agricultural and industrial goods, and in real output. The output of the industrial sector fluctuates to a lesser degree, for according to the equations in the model, entrepreneurs base their decisions upon average rather than instantaneous measurements of demand. Employment in private industry also fluctuates to a lesser degree, but the price of industrial goods, responding immediately to shifts in demand, fluctuates to a greater degree. As wages are relatively inflexible, and prices flexible, revenues fluctuate more widely than do costs. Entrepreneurial income, being the residual after costs are met, fluctuates still more widely, and, more important, is greater on the average than in the absence of random inputs. Capitalists appear to do better when prices are unstable.

When the fraction of the total industrial demand supplied by local firms within the Northeast fluctuates in a random fashion, the general behavior in the system is much the same. Industrial output varies, and

industrial employment, wages, prices, and income vary in response. That sector on which the random forces impinge exhibits fluctuations roughly proportional in magnitude, and the other sectors exhibit fluctuations that are dampened. The greatest fluctuation occurs in industrial employment. Employment in private industry exhibits swings of approximately twice the amplitude of the random inputs: for example, $\pm$ 20 percent when the random input was $\pm$ 10 percent (of the fraction supplied locally -- FIØN in Eq. 29). When the fluctuations originate in the agricultural sector, agricultural income varies most; when the fluctuations originate in the industrial sector, employment varies most.

The third set of cases which were simulated with random inputs were those in which the shocks impinged upon entrepreneurs' decisions to invest in their firms. Instead of entrepreneurs devoting half their expenditures on industrial goods to investment, the fraction was allowed to fluctuate by a maximum of $\pm$ 10 percent, so that investment could be as little as 0.45 of expenditures, or as much as 0.55. Over the simulation period (1960 to 1985), the fluctuations in all of the other variables in the system tended to be less than those in investment. The reason for this dampening is that industrial output, employment, wages, and so on are affected by the total capital stock in industry, rather than by yearly additions and subtractions. Fluctuations in investment of the order of those simulated yield very slight fluctuations, of the order of $\pm$ one percent in capital stock, in incomes (even those of capitalists), and in demand.

Slightly lower growth rates were observed in all the cases with random fluctuations. The reason for this phenomenon is more difficult to determine. One finds that the price of industrial goods is a little higher, capital stock a little lower, and industrial output and employment only slightly lower than in the base case. The cause appears to be fluctuations in industrial productivity: as entrepreneurs expand output, they are forced to hire labor whose marginal productivity is less than that of the labor already employed. The additional workers contribute less, on the average, than do those who preceded them. To

be sure, there is a slight increase in average productivity when industrial output is reduced, but this is not enough to compensate for the loss when output increases. Had we chosen a production function with constant returns to scale, these net losses would not have occurred, but as our production function exhibits varying returns and as our firms are operating within the range of decreasing returns to scale, the loss in output is bound to occur.

The fluctuations in the harvest, in the fraction of industrial products supplied locally, and in the investment of entrepreneurs were all random departures from regular trends. One different type of random input was tried, in which the effect of any single random component persisted. The variable to which the random component was attached was the number of firms in private industry (NFI in Eq. (13)), and persistence was achieved by having the present value of NFI depend upon the previous value inflated or deflated by the random component. The equation for the number of firms in existence was thus equivalent to

$$NFI_i = (NFI_{i-1})(RAND(DUM))\ e^{\alpha(TEBS)}$$

where alpha is a constant. A very large random component would raise NFI immediately, and, because the next value of NFI depended upon the previous one, all subsequent values too. This compound sequence is also random, but unlike the simple sequence it leaves an imprint upon the history, for the period of the fluctuation is long relative to the length of the simulation. As an example, in one case in which the growth of the number of firms was, on the average, equal to 10 percent per year and the random fluctuations were of the severity of $\pm$ 10 percent of NFI, the number of firms in existence in 1980 varied by $\pm$ 50 percent. Had there been no random component, the number of firms in the Northeast would have increased (at the rate of 10 percent per year) to 72,800. With the random component, the number of firms in 1980 ranged widely, over all the various cases, from 39,000 to 132,900.

The only difference between these cases was a different sequence of random numbers. If, by chance, the first few random numbers all happened to be positive, the number of firms would, several years later, still be substantially greater than if the first few random numbers had been negative. Intervening events would not be likely to cancel out the initial effects. It seems, therefore, that random forces, even though they may not be great in amplitude, can, if the system permits them to persist, cause notable differences in performance over as long as a generation.

The system describing the economy of the Northeast is relatively stable. It absorbs single shocks with some ease and readily dampens continuous shocks. The shocks must be fairly large in order to cause the system to deviate from its normal growth path, and very large to cause it to fluctuate. Quantitatively, the system's behavior is altered by shocks of such magnitude as one might find in a real economy; qualitatively, the system behaves differently only when subjected to the greatest of blows.

We are not greatly surprised at the ability of the system to absorb shocks, for we have padded it with some cushions. Many equations have as their independent variable TEBS, indicating that they are independent of all forces save the passage of time. Additionally, at two points, average rather than instantaneous values are used in calculations; one is the decision of the entrepreneur to vary output and the other is the adjustment of the wage rate in the labor market. The former, implicitly, permits the accumulation or decumulation of stocks, and the latter makes the wage rate less volatile. Several variables -- for example employment in agriculture and by government, population growth, investment, and consumption -- are little affected by shocks, continuing along their customary paths regardless of what happens elsewhere in the model.

THE EFFECTS OF CHANGES IN THE POPULATION GROWTH RATE: CASES RGP-A, -B, AND -C

Having submitted the system to all manners of shocks, we now vary, singly, the values of some parameters, choosing those that relate to population growth, capital investment, technological progress, self-sufficiency, time delays, and product demand. For each of these we first discuss the alterations to the base case; second, describe the results, in particular as they vary from those of the base case; and third, draw conclusions as to the sensitivity of the system.

In considering changes in the population growth rate of the Northeast, we choose two alternatives, one higher and one lower, than the value assumed in the base case. The changes will be relatively small, from a growth rate of 3 percent per year to ones of 2.9 percent, 3.1 percent, and 3.5 percent per year; these will be the only changes made in the inputs to the model. The results of the base case and of the simulations with the three alternative values for one year, 1980, are summarized in Table 16; in Fig. 18, employment of the population groups over the entire period is given. It appears that the population employed in private industry increases very little as the total population grows. The change in the latter is approximately 3 percent per year, the change in the former approximately 2 percent. Raising the growth rate of the population from 2.9 percent to 3.0 percent produces an increase in employment of 2.3 percent; raising it again from 3.0 percent to 3.1 percent produces an additional 1.6 percent increase in employment.

Since employment increases by less than the population growth rate, unemployment increases by much more. Once again using the figures for 1980, the increase in the rate of growth in the population from 2.9 percent to 3.0 percent per year leads to a rise in unemployment of 21 percent. The increase from 3.0 percent to 3.1 percent leads to a rise in unemployment of 21.6 percent. The idle take up the slack.

If the population growth rate were to increase still further, the rate of increase of employment would become smaller, and that of unemployment greater; in other words, employment is increasingly inelastic

Table 16

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN THE POPULATION GROWTH RATE

Variables		Values					
Definition	Symbol	Base Case	RGP-A	RGP-B	RGP-C		
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP	0.03	0.029	0.031	0.035		
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Est. new firms	NFEKC						
To invest	APIKC						
Price elasticity	PEAAC						
Income elasticity	YEAAC						
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	16112	16770	18167		
In agriculture	PEA	12044	→	→	→		
In government	PEG	1757	→	→	→		
Entrepreneurs	PØKI	27	→	→	→		
In industry	PEI	1175	1148	1194	1238		
Unemployed	PU	1436	1137	1748	3101		
Fraction employed	FAEI	0.45	0.50	0.41	0.29		
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	→	→	→		
Ind. output (000,000)	ØIS	488	483	490	498		
Capital stock (000,000)	KI	11364	11357	11369	11380		
Efficiency	EFFI	0.755	0.765	0.748	0.733		
Number of firms	NFI	26700	→	→	→		
Price of ind. goods	DPIØ	5.6	5.7	5.6	5.5		
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1316	1315	1298		
In govt., per capita	TCPCG	5998	5973	6012	6050		
Of capital, per capita	TCPCK	64210	63690	64620	63736		
In ind., per capita	TCPCI	1689	1723	1660	1605		
Unemployed, per capita	TCPCU	423	440	406	351		
Average per capita	TCPC	1866	1894	1836	1836		
Total income (000,000)	TC	30686	30517	30796	33344		
Output per capita	RØPC	1019	1036	1000	929		
Total output (000,000)	RØ	16750	16700	16770	16860		
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→	→		
Ag. inv. (000,000)	EGA	1335	→	→	→		
Ind. inv. (000,000)	EGKI	1227	→	→	→		

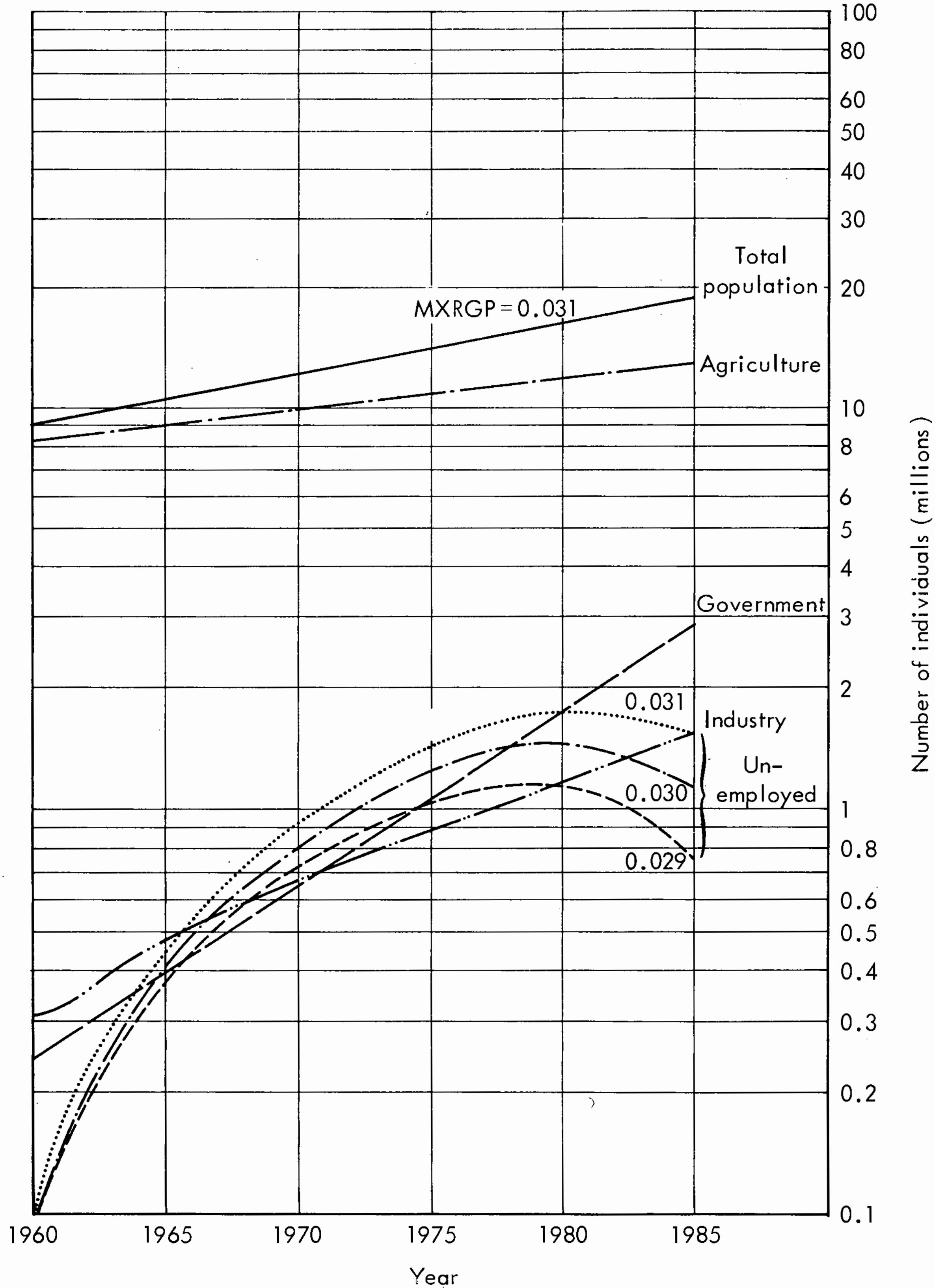

Fig. 18—Variations in unemployment with variations in the rate of growth of population, from 2.9% to 3.0% to 3.1% per year, 1960-1985

with increases in the growth of the population and unemployment increasingly elastic. When the population growth rate rises to 3.5 percent (see Table 16, case RGP-C), employment increases by very little, almost all the additional individuals being destined to be unemployed.

As the size of the industrial labor force increases, there is substitution of labor for capital in private industry. The shifts in the stock of capital in industry are not very large, however: at the population growth rate of 2.9 percent and the relatively low wage rate, the amount of capital being used is equal to 11,357 million baht; at 3 percent it is equal to 11,364 million baht. While unemployment has increased by 25 percent, employment has increased by only 2 percent and capital stock in industry has decreased by only 0.1 percent. Very little of the abundant factor of production has been substituted for the scarce factor.

We can observe a few other changes between the base case, in which the rate of growth of the population is 3 percent per year, and our alternatives with rates of 2.9 percent and 3.1 percent. The higher the rate of growth of the population, and of unemployment, the later the peak in unemployment is reached. When population growth rate is 2.9 percent per year, the peak in unemployment (1,160,000 persons) occurs in 1979; when it is 3 percent per year, the peak in unemployment (1,440,000) occurs in 1980; and when it is 3.1 percent per year, the peak (1,760,000) occurs in 1981. Moreover, the slower the rate of growth of the population, the sooner is unemployment eliminated. The system responds more quickly and with less waste at lower population growth rates.

As we may expect, resources are used more effectively at lower rates of growth of the population; as population increases from a rate of 2.9 percent per year to one of 3.0 percent and finally to one of 3.1 percent, real output per capita decreases from 1,036 to 1,019 to 1,000 baht per year, and the efficiency of the utilization of inputs in industrial production falls from 0.765 to 0.748 (versus 1.000 when inputs are used optimally).

Although the effects on real income of the changes in population growth rate are what we might expect, they are nonetheless important. Consumption by the two groups -- the population employed in agriculture and by government -- varies little (see Table 16). Money income for these groups has not changed, and their disposable income has varied only through changes in their gifts to the unemployed. The real income of capitalists changes hardly at all, although the slight change that does occur is in the opposite direction from that of the other groups. As the growth rate of the population increases and the efficiency of production in private industry decreases, the returns to private businessmen increase. By using more labor when it is abundant, capitalists can more than offset the fall in prices of their products.

Real income of the population employed in private industry falls in nearly the same proportion as the population growth rate rises; and the income which the unemployed receive, as gifts, falls in greater than the same proportion. The burden of higher population growth rates, therefore, is borne lightly by those who are fortunate enough to secure employment in the private sector and heavily by those who lack this good fortune.

THE EFFECTS OF CHANGES IN THE RATES OF TECHNOLOGICAL PROGRESS: CASES TPROG-A THROUGH -E

Another rate of growth, which is generally beneficial, is that of technological progress. Whenever more output is obtained from the same input, the society as a whole will benefit, as will, most likely, each of the groups within it. In the model we include three different variables measuring overall technological progress: one is the rate of increase of productivity in agriculture and the others are the rates of increase of the maximum obtainable output and of the extension of the range of economies of scale in industry. In the base case, the rate of technological progress in agriculture is assumed to be 1 percent per year; and in industry, 2 percent per year for the growth of maximum output and 1 percent per year in the extension of the economies

of scale. In the first of the alternate simulations we cut these rates in half, so that they were 0.5 percent, 1.0 percent, and 0.5 percent, respectively. In the second variation we increased the rates by 50 percent over the base case, so that they were 1.5 percent, 3 percent, and 2 percent, respectively. In the third variation we left the two rates for industry unchanged (at 3 percent and 2 percent, respectively) and increased the rate of technological progress in agriculture to 3 percent per year.

In the fourth and fifth variations we reversed the trends, reducing the rate of progress in agriculture and raising it in industry: to 0 percent, 2 percent, and 1 percent, respectively, in the fourth case; and to 1 percent, 3 percent, and 2 percent, respectively, in the final case.

These variations are summarized in Table 17, and lead us to the following conclusions. First, as the rates of technological improvement concurrently increase, employment in private industry rises slightly. Of necessity, with no change in population, unemployment falls by an equal amount. The stimulus is an increase in the demand for industrial goods, predominantly on the part of those employed in agriculture. As they are a large fraction of the total population, slight increases in their incomes and expenditures produce great increases in industrial demand and output. Doubling the rates, from the first variation to the base case, yields an increase in total output of 12 percent; increasing them by a further 50 percent from the base case, in the second variation, yields an additional increase of total industrial output of 10 percent.

In the third variation, technological progress in agriculture speeds up without speeding up in industry; and in the fifth the reverse happens. The effects are symmetrical and will be displayed by comparing the third case (TPROG-C) with the second (TPROG-B). As agricultural productivity rises so do agricultural incomes. Since industrial wages are linked to those in agriculture, they too rise, leading to a substantial increase in industrial costs and prices.

Table 17

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN THE RATES
OF TECHNOLOGICAL PROGRESS

Variables		Values					
Definition	Symbol	Base Case	TPROG-A	TPROG-B	TPROG-C	TPROG-D	TPROG-E
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2	0.01	0.005	0.015	0.03	0.00	0.01
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3	0.02	0.010	0.030	→	0.02	0.03
	CØIC 5	0.01	0.005	0.020	→	0.01	0.02
PROPENSITIES							
Est. new firms	NFEKC						
To invest	APIKC						
Price elasticity	PEAAC						
Income elasticity	YEAAC						
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→	→	→	→
In agriculture	PEA	12044	→	→	→	→	→
In government	PEG	1757	→	→	→	→	→
Entrepreneurs	PØK1	27	→	→	→	→	→
In industry	PEI	1175	1145	1242	1133	1268	1285
Unemployed	PU	1436	1466	1368	1478	1343	1326
Fraction employed	FAEI	0.45	0.44	0.48	0.43	0.49	0.49
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	12274	14992	20238	11107	13565
Ind. output (000,000)	ØIS	488	421	535	519	499	542
Capital stock (000,000)	KI	11364	11341	11219	11474	11212	11145
Efficiency	EFFI	0.755	0.766	0.739	0.764	0.731	0.850
Number of firms	NFI	26700	→	→	→	→	→
Price of ind. goods	DPIØ	5.6	6.0	5.4	6.6	5.0	5.1
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1139	1481	1656	1168	1398
In govt., per capita	TCPCG	5998	5698	6221	5373	6513	6402
Of capital, per capita	TCPCK	64210	60490	60270	60880	64234	60325
In ind., per capita	TCPC1	1689	1455	1923	2230	1520	1827
Unemployed, per capita	TCPCU	423	375	470	524	397	455
Average per capita	TCPC	1866	1675	2022	2161	1806	1987
Total income (000,000)	TC	30686	27552	33232	35550	29670	32650
Output per capita	RØPC	1019	910	1121	1392	895	1052
Total output (000,000)	RØ	16750	14940	18460	22940	14711	17286
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→	→	→	→
Ag. inv. (000,000)	EGA	1335	→	→	→	→	→
Ind. inv. (000,000)	EGKI	1227	→	→	→	→	→

As a consequence, demand for industrial goods and employment in industry fall; comparing the second and third variations, we find that the effects of doubling the rate of technological progress in agriculture alone are a reduction in industrial output from 535,000 to 519,000 units; a reduction in industrial employment from 1,242,000 to 1,133,000 persons; an increase in capital employed in industry from 11,219,000 to 11,474,000 baht; and an increase in the price of industrial goods from 5.4 to 6.6 baht per unit. With the reduction in employment and output, the efficiency with which inputs are combined increases from 0.739 to 0.764. Because resources in industry are used more effectively, the real incomes of labor rise and the profits of capitalists are maintained. But when both agricultural and industrial productivity increase simultaneously, the income of entrepreneurs and their share in the total income of the region fall. If one wishes to reduce unemployment, and to limit disparities in the distribution of income, apparently one must increase productivity in both sectors simultaneously; it is not enough to increase the productivity in one sector alone.

THE EFFECTS OF CHANGES IN INVESTMENT RATE IN INDUSTRY: CASES PINV-A AND -B

The next set of simulations considers variations in the average propensity to invest of the owners of private firms in the modern sector. Originally, we assumed that half of all industrial goods bought by entrepreneurs represented investment in their firms; now we assume that the fractions are 0.4 and 0.6. Otherwise, there are no changes from the base case.

It makes little difference whether the average propensity to invest our of purchases of industrial goods is 0.4, 0.5, or 0.6 (see Table 18). At the lowest propensity, the total capital stock in industry in 1980 is 10,868 million baht; at the middle, 11,364 million baht; and at the highest, 11,867 million baht. Increasing the average propensity to invest from 0.4 to 0.5 produces an increase in total

Table 18

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN ENTREPRENEURS' PROPENSITY TO INVEST

Variables		Values					
Definition	Symbol	Base Case	PINV-A	PINV-B			
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Est. new firms	NFEKC						
To invest	APIKC		0.4	0.6			
Price elasticity	PEAAC						
Income elasticity	YEAAC						
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→			
In agriculture	PEA	12044	→	→			
In government	PEG	1757	→	→			
Entrepreneurs	PØKI	27	→	→			
In industry	PEI	1175	1173	1176			
Unemployed	PU	1436	1437	1435			
Fraction employed	FAEI	0.45	0.45	0.45			
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	→	→			
Ind. output (000,000)	ØIS	488	479	496			
Capital stock (000,000)	K1	11364	10868	11867			
Efficiency	EFFI	0.755	0.773	0.739			
Number of firms	NFI	26700	→	→			
Price of ind. goods	DPIØ	5.6	5.7	5.5			
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1304	1326			
In govt., per capita	TCPCG	5998	5943	6047			
Of capital, per capita	TCPCK	64210	63080	65320			
In ind., per capita	TCPCI	1689	1674	1701			
Unemployed, per capita	TCPCU	423	419	426			
Average per capita	TCPC	1866	1851	1882			
Total income (000,000)	TC	30686	30420	30930			
Output per capita	RØPC	1019	1012	1022			
Total output (000,000)	RØ	16750	16660	16830			
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→			
Ag. inv. (000,000)	EGA	1335	→	→			
Ind. inv. (000,000)	EGKI	1227	→	→			

capital stock of 4.4 percent, whereas output rises by only 1.8 percent, from 479 million units per year to 488 million. Increasing the average propensity to invest still more, from 0.5 to 0.6, produces an increase in total capital stock of 4.2 percent and in output of 1.6 percent. In both cases changes in employment are positive in direction, although small in amount.

There does appear to be a slight redistribution of income from labor to capital as the capitalists' rate of investment rises. There is certainly a reduction in the average productivity of resources in industry, as well as a reduction in the price of industrial goods.

Our conclusion is that the model is relatively insensitive to changes in investment by the owners of private industry, and that as investment rises, increases in employment and output become progressively smaller. This is not surprising as the firms are operating in the range of decreasing returns to scale, where the marginal productivity of additional resources is declining. Moreover, in our model the capitalist is only one of two investors; the government also contributes capital to industry. In 1960, at the beginning of the simulation, investment by capitalists is 79 million baht a year and that of the government is 166 million. In 1980, the investment by capitalists increases to 350 million baht per year and that of government increases to 1,230 million. By 1980, the cumulative investment of entrepreneurs is 4,061 million baht, that of government 10,659 million baht. Thus, government investment in industry is greater at the beginning, and is increasing more rapidly, than private investment; yet it is private investment that we are varying in these cases.

THE EFFECTS OF INCREASING OR REDUCING THE INSUFFICIENCY OF REGIONAL OUTPUT: CASES FRNE-A THROUGH -E

When formulating the model of the economy of the Northeast, we were confronted with the problem of deciding what portion of any increase in the demand for industrial goods would be supplied out of production in the Northeast and what portion would be supplied from the rest of Thailand. Economic theory was no help, so we assumed in

the base case that the fraction of total demand produced locally remained constant. To determine how the model would behave if the portion produced locally were to vary, we simulated its behavior under five different sets of conditions as shown in Table 19. The first four of these assumed steady increases at annual rates of 1, 2, 3, and 5 percent per year, and the fifth a decrease at the rate of 5 percent per year.

The fraction of total industrial demand actually supplied by firms operating in the Northeast in 1960 was estimated in Section VIII to be 0.35. In the base case the same fraction persists throughout the entire run; but in the first variation, where it increases at the rate of 1 percent per year, it has reached 0.43 by 1980; in the second case, at 2 percent per year, 0.52; in the third case, at 3 percent per year, 0.64; and in the fourth case, at 5 percent per year, 0.95. Thus, if private firms in the Northeast each year were to supply 5 percent more of the industrial goods demanded, by 1980 the region would be nearly self-sufficient.

As the fraction of total industrial demand supplied locally rises (see Table 19) so must industrial capacity and employment. Other variables that also increase are the fraction of the total work force employed, output per capita, and, particularly, the price of industrial goods. By 1980, in the third variation, the price of industrial goods has risen to nearly its original 1960 value of 10 baht per unit; in the fourth case it exceeds the original value.

Since price rises so substantially, demand for industrial goods falls as consumers find that they are able to buy less with their incomes. In our successive variations, producers in the Northeast are supplying ever larger fractions of even smaller total consumption. This can be observed by comparing the increases in the output of firms in the Northeast with the increases in the fraction supplied locally. When firms in the Northeast supply 35 percent of total demand, their output is 488 million units; when they supply approximately 65 percent, their output is 588 million units; and when they supply nearly 100 percent, 636 million units. Thus, as the fraction supplied out of regional

Table 19

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN THE FRACTION OF TOTAL DEMAND FOR INDUSTRIAL GOODS SUPPLIED BY THE REGION

Variables		Values					
Definition	Symbol	Base Case	FRNE-A	FRNE-B	FRNE-C	FRNE-D	FRNE-E
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2	0.0	0.01	0.02	0.03	0.05	-0.05
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Est. new firms	NFEKC						
To invest	APIKC						
Price elasticity	PEAAC						
Income elasticity	YEAAC						
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→	→	→	→
In agriculture	PEA	12044	→	→	→	→	→
In government	PEG	1757	→	→	→	→	→
Entrepreneurs	PØKI	27	→	→	→	→	→
In industry	PEI	1175	1384	1615	1849	2232	493
Unemployed	PU	1436	1226	996	761	379	2117
Fraction employed	FAEI	0.45	0.53	0.62	0.71	0.85	0.19
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	→	→	→	→	→
Ind. output (000,000)	ØIS	488	624	557	588	636	303
Capital stock (000,000)	KI	11364	11744	12200	12752	14263	10180
Efficiency	EFFI	0.755	0.684	0.622	0.568	0.489	1.230
Number of firms	NFI	26700	→	→	→	→	→
Price of ind. goods	DPIØ	5.6	6.5	7.6	9.0	13.7	3.3
Fraction pro. locally	FIØN	0.351	0.428	0.523	0.639	0.953	0.129
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1214	1117	1029	869	1891
In govt., per capita	TCPCG	5998	5470	4985	4324	3731	8979
Of capital, per capita	TCPCK	64210	74470	81960	72380	118730	31830
In ind., per capita	TCPCI	1689	1618	1576	1575	1769	2129
Unemployed, per capita	TCPCU	423	407	391	382	363	532
Average per capita	TCPC	1866	1757	1662	1572	1477	2530
Total income (000,000)	TC	30686	28927	27325	26008	24270	41604
Output per capita	RØPC	1019	1041	1061	1080	1109	908
Total output (000,000)	RØ	16750	17100	17440	17750	18230	14900
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→	→	→	→
Ag. inv. (000,000)	EGA	1335	→	→	→	→	→
Ind. inv. (000,000)	EGKI	1227	→	→	→	→	→

production rises, so does local output, but by lesser and lesser amounts.

Capital stock and employment also rise as entrepreneurs attempt to produce more, the increase in employment being the more pronounced. As the fraction supplied out of local production increases from an annual rate of 0 to 1 percent, from 1 to 2 percent, and from 2 to 3 percent, employment rises by 15 percent, 14 percent, and 13 percent, and capital stock by 3.2, 3.7, and 4.3 percent, respectively. Thus the increases in capital stock are at increasing rates from a low initial value, and the increases in employment are at decreasing rates from a high initial value. Capital is increasingly substituted for what becomes very expensive labor.

To see how the system might respond to sudden changes in the fraction of industrial goods manufactured locally, we simulated four additional cases in which there were shifts (in the year 1970) from 0.35 in the base case to, separately, 0.28, 0.315, 0.385, and 0.42. In the long run the effects of sudden shifts in the fraction produced locally were no different from those of gradual changes; both sporadic and steady movements ultimately yield the same results. But in the years immediately after the sudden shifts, there were the same sorts of adjustments that we noticed when we changed (equally suddenly) agricultural productivity and industrial wages, and the same irrecoverable losses (in the first two variations) or unalienable gains (in the last two variations).

THE VARYING EFFECTS OF PROFITS IN THE RATE OF ESTABLISHMENT OF NEW FIRMS: CASES NFEK-A THROUGH -C

The rise in the price of industrial goods consequent upon the substantial increase in local production indicates a fall in the efficiency of manufacture, as firms, expanding output rapidly to meet increases in demand, operate at higher and higher levels of unit costs. Perhaps prices will not rise at quite this rate, however, for new firms may be attracted by the sight of the profits accruing to existing firms, a possibility we excluded in previous variations. To determine what

might be the effects of a more liberal creation of new firms, we simulated three additional cases, in which the rate of growth of new firms varied according to the income of entrepreneurs.

The relationship between the number of new firms and entrepreneurial income (Eq. 11) remained the same for the three cases; as the per capita income of entrepreneurs rises, so, in equal proportions, does the number of new firms. Also, as the population available for employment in the private sector, and thus available to create the new firms, rises, so does the number of new firms. The constant of proportionality is the parameter NFEKC, which takes on the three values of $2x10^{-9}$, $4x10^{-9}$, and $6x10^{-9}$.

The results of the simulations are summarized for the year 1980 in the lower half of Table 20. There we see that, as the constant of proportionality rises, so, necessarily, does the number of new firms created each period and the total number in existence at any time. The rate of creation of new firms is less than proportional to the rate of increase of the constant NFEKC, however; for industry profits are divided among more and more entrepreneurs, and the decline in per capita income of entrepreneurs tends to offset the increase in the value of the constant.

Total profits from industry do not remain constant but decline steadily from 1.17 billion baht per year in the base case to 1.04, 0.92, and 0.83 billion baht in the three variations, because the existence of excess capacity reduces the entrepreneurs' share of the total product. Once the rate of growth of new firms exceeds the rate of growth of demand for industrial products minus the rate at which the range of economies of scale is extended (as it does in even the first of the three variations), the individual firms are all operating at outputs less than those at which minimum average costs are obtained. This is indicated by the values of EFFI, the measure of the efficiency with which resources are combined. When firms are operating at a level of output above that which yields minimum average cost, EFFI is less than unity; at that which yields minimum average cost, EFFI is equal to unity; and at levels of output below minimum average cost,

Table 20

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN THE PROFIT-INDUCED CREATION OF NEW FIRMS

Variables		Values					
Definition	Symbol	Base Case	NFEK-A	NFEK-B	NFEK-C		
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Est. new firms	NFEKC	0	$2x10^{-9}$	$4x10^{-9}$	$6x10^{-9}$		
To invest	APIKC						
Price elasticity	PEAAC						
Income elasticity	YEAAC						
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→	→		
In agriculture	PEA	12044	→	→	→		
In government	PEG	1757	→	→	→		
Entrepreneurs	PØKI	27	50	64	75		
In industry	PEI	1175	1252	1276	1286		
Unemployed	PU	1436	1334	1296	1276		
Fraction employed	FAEI	0.45	0.48	0.50	0.50		
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	→	→	→		
Ind. output (000,000)	ØIS	488	485	419	360		
Capital stock (000,000)	KI	11364	11079	10873	10710		
Efficiency	EFFI	0.755	1.39	1.79	2.10		
Number of firms	NFI	26700	50344	64629	75390		
Price of ind. goods	DPIØ	5.6	5.6	6.3	7.1		
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1322	1232	1150		
In govt., per capita	TCPCG	5998	6018	5573	5163		
Of capital, per capita	TCPCK	64210	29249	18569	13232		
In ind., per capita	TCPCI	1689	1720	1613	1510		
Unemployed, per capita	TCPCU	423	431	407	384		
Average per capita	TCPC	1866	1868	1729	1600		
Total income (000,000)	TC	30686	30717	28410	26330		
Output per capita	RØPC	1019	1017	977	941		
Total output (000,000)	RØ	16748	16716	16058	15466		
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→	→		
Ag. inv. (000,000)	EGA	1330	→	→	→		
Ind. inv. (000,000)	EGKI	1227	→	→	→		

EFFI is greater than unity. In all three cases EFFI is greater than unity, average costs are high, and there is not sufficient demand to absorb all of the cost increase. (In the next section, cases NFEG-A and NFEG-B display the behavior of the model when the rate of growth of new firms is just such as to enable resources to be used most efficiently.)

As entrepreneurial income declines, so do entrepreneurs' savings, and at a faster rate, because of their greater-than-unitary income elasticity. Therefore, beyond the number necessary to maintain minimum average costs, the higher the rate of establishment of new firms, the lower the stock of capital in industry. Employment in industry rises as investment falls, for entrepreneurs substitute more of the abundant input (labor) for the scarce one (capital). When efficiency rises (that is, when the number of firms in 1980 grows from the 26,700 in the base case to somewhat less than the 50,000 in case NFEK-A), so does total industrial output, the amount of industrial goods that can be bought with a fixed number of baht, and the real income of all groups other than capitalists. But when efficiency begins to decline (that is, when the number of firms exceeds 50,000), so do industrial output and real incomes. The latter declines might be mitigated by competition among the firms, each trying to expand output so as to be able to produce at lower unit cost, but we do not have any such competitive mechanism in our model.

THE EFFECTS OF VARYING LAGS IN PRODUCTION DECISIONS AND WAGE DETERMINATION: CASES TCIAV AND WEIAV-A AND -B

In any economy there are buffers, such as inventories, that absorb fluctuations or dampen shocks. In our model there are two such cushions, one inserted in entrepreneurs' decisions on production levels and the other in the determination of the industrial wage rate. To see how changing their resilience might affect the behavior of the model, we simulated three alternative cases. In one variation we changed the weights attached to more recent and less recent data on output, and in two other variations we changed the weights on more recent and less recent values of wage rates.

The effects of changing the weights in the production decision (Eq. 29A, formulated in Section IV) were predictable in their direction and slight in their impact (see Table 21, case TCIAV). As population, employment, and income are all rising steadily, attaching greater weights to more recent values of demand results in increases in output, in employment in industry, in the price of industrial goods, and in real income. The only detraction is a reduction in efficiency, as entrepreneurs operate their firms beyond the output at which minimum average cost is obtained.

Changing the weights attached to more recent and less recent values of the wage rate has little apparent effect (see Table 21, cases WEIAV-A and -B). Weighing the most recent value of the wage rate more heavily, which is equivalent to making wages more flexible, produces a slightly lower employment in industry and, consequently, a slightly greater efficiency in the allocation of resources. Capital is substituted for labor, though, so that the change in output is even smaller.

THE EFFECTS OF CHANGES IN DEMAND ELASTICITIES: CASE ELAS

The final variation in parameter values incorporated changes in the elasticities of demand (Table 21, case ELAS). The income elasticities for agricultural goods for all the population groups were increased from 0.9 in the base case to 0.95; and those for industrial goods were lowered from 1.1 to 1.05. The price elasticities were left unchanged, but the cross-elasticities had to be altered so that the sums of all the elasticities for agricultural goods, and for industrial goods, were each equal to unity; the changes from the base case were from -0.1 to -0.15, and from 0.1 to 0.05, for agricultural and industrial goods, respectively.

Raising the income elasticity for agricultural goods and lowering it for industrial goods reduces employment, output, and prices in private industry. In curtailing output, entrepreneurs reduce employment and capital stock by 4 percent each over the base case. Cutting back on both factor inputs cuts back output as well, but by only

Table 21

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN TIME FACTORS AND ELASTICITIES

Variables		Values				
Definition	Symbol	Base Case	TCIAV	WEIAV-A	WEIAV-B	ELAS
INPUTS - 1960						
LAG COEFFICIENTS						
Wt. of past consumption	TCIC 1	0.9	0.8	0.9	→	→
Wt of present consumption	TCIC 2	0.1	0.2	0.1	→	→
Wt. of past wage	WEIC 1	0.9	→	0.8	0.95	0.9
Wt. of present wage	WEIC 2	0.1	→	0.2	0.05	0.1
PROPENSITIES						
Price elas., food	PEAAC	-0.8	→	→	→	→
Income elas., food	YEAAC	0.9	→	→	→	0.95
Cross elas., ind.	CEAAC	-0.1	→	→	→	-0.15
Cross elas., food	CEIAC	0.1	→	→	→	0.15
Income elas., ind.	YEIAC	1.1	→	→	→	1.05
GOVERNMENT POLICIES						
Growth of ag. inv.	EGAC					
Initial ag. inv.	EGAC 1					
Growth of ind. inv.	EGKIC					
Initial ind. inv.	EGKIC 1					
Est. new firms	NFEGC					
Growth of civil serv.	INPEG					
Growth of salaries	IWEGC					
Family planning	IDRGIP					
OUTPUTS - 1980						
OCCUPATIONAL GROUPS (000)						
Total population	PT	16438	→	→	→	→
In agriculture	PEA	12044	→	→	→	→
In government	PEG	1757	→	→	→	→
Entrepreneurs	PØKI	27	→	→	→	→
In industry	PEI	1175	1212	1167	1187	1133
Unemployed	PU	1436	1398	1443	1423	1477
Fraction employed	FAEI	0.45	0.46	0.45	0.45	0.43
PRODUCTION, ETC.						
Ag. output (000)	ØAS	13565	→	→	→	→
Ind. output (000,000)	ØIS	488	495	487	490	473
Capital stock (000,000)	KI	11364	11464	11364	11363	10874
Efficiency	EFFI	0.755	0.738	0.758	0.749	0.785
Number of firms	NFI	26700	→	→	→	→
Price of ind. goods	DPIØ	5.6	5.7	5.6	5.6	5.5
INCOMES (baht per year)						
In ag., per capita	TCPCA	1316	1295	1313	1320	1532
In govt., per capita	TCPCG	5998	5900	5996	6066	6968
Of capital, per capita	TCPCK	64210	65770	64060	64490	68398
In ind., per capita	TCPCI	1689	1671	1692	1674	1958
Unemployed, per capita	TCPCU	423	420	422	424	488
Average per capita	TCPC	1866	1845	1865	1870	2160
Total income (000,000)	TC	30686	30328	30635	30738	35430
Output per capita	RØPC	1019	1023	1018	1020	1010
Total output (000,000)	RØ	16748	16820	16740	16770	16599
GOVERNMENT EXPENDITURES						
Total (000,000)	EG	10433	→	→	→	→
Ag. inv. (000,000)	EGA	1330	→	→	→	→
Ind. inv. (000,000)	EGKI	1227	→	→	→	→

3 percent. The reduced pressure on resources in industry results in their being used more efficiently, the measure (EFFI) rising from 0.755 to 0.785, and in the price of industrial goods falling, from 5.6 to 5.5 baht per unit. Employed groups (agricultural workers and civil servants), which have fixed money income, benefit from the lower price of industrial goods; part of the burden is borne by the newly unemployed.

Although total production of both industrial and agricultural goods (RØ) declines, total consumption (TC) rises substantially. The reason for this anomaly is that we held the price of agricultural goods fixed so that it did not rise even though there was a great rise in their demand: in the base case the net deficit of agricultural goods in the Northeast (TCAØ-ØAS) in 1980 was 4,279,000 tons per year; with the higher income elasticity of demand for agricultural goods it was 10,233,000 tons per year, more than double. It is doubtful that the Thai government would subsidize the consumption of food in the Northeast to this extent, for it would mean forgoing the income obtained from the export of rice: the other part of the burden would probably not be borne.

THE EFFECTS OF VARYING THE STRUCTURE OF THE MODEL -- DIFFERENT PRODUCTION FUNCTION IN INDUSTRY

From varying the values of the parameters we move on to altering the structure of the model. The criterion that we shall follow -- namely changing relationships in which we have the least confidence -- is the same as the one we followed in changing the values of the parameters. The procedure will be to describe the differences from the model of the base case, observe the behavior of the new model, and generalize wherever possible.

Most of the changes that we shall make in the structure of the model have been hinted at during its formulation. The most important (the change in the rate of growth of the population) we reserve for the next section, where we discuss alternative government policies. Three others are to be considered here. The first is a different

production function for private firms in the modern sector, the second is an agricultural production function with variable coefficients, and the third is a different formulation of the labor supply schedule.

The production function that we have used for industry is unique to this study. Conventional production functions, like the one with fixed coefficients which we used in describing production in agriculture, and the few others with variable coefficients, assume no variations in the returns to scale. Examples of the latter are the Cobb-Douglas and the CES production functions, which can exhibit constant, increasing, or decreasing returns to scale but never a combination. Mathematically, the Cobb-Douglas is the simpler of the two and can be expressed in our terminology as

$$\text{ØIS}_i = e^{(\text{CØIC6})(\text{TEBS}_i)}\ (\text{ØFIC4})(\text{KI}_i)^{(\text{ØFIC5})}\ (\text{PEI}_i)^{(\text{ØFIC6})}$$

where

ØIS = Output of the Industrial Sector, units per year,

CØIC6 = Coefficient used in determining Output of Industry, a Constant, and equivalent to the annual rate of increase of productivity,

TEBS = Time Elapsed since the Beginning of the Simulation, years,

KI = c(K)apital in private Industry, baht,

PEI = Population Employed in private Industry, number of individuals, and

ØFIC4, 5, 6 = coefficients used in Output Function for Industry, Constants, various dimensions.

It is this production function that we shall apply to private industry in the modern sector, using the same two variables, labor and capital, to produce the same output, homogeneous industrial goods, as in our original model. The division of the total product between labor and capital remains the same as before, each group receiving one-half (thus ØFIC5 and 6 = 0.5).

We shall not assume that there are either steadily increasing or decreasing returns to scale in industry, but rather that there are constant returns. If resources are increased in (proper) proportions, output will increase in the same proportion; a doubling of inputs would produce a doubling of output, and so on. The productivity of the inputs is unaltered. The number of firms is no longer of any consequence so far as the efficiency of production is concerned, but it does affect entrepreneurial income per capita because of the varying number of entrepreneurs among whom profits are to be divided, and it affects private investment because of the greater-than-unitary elasticity of expenditure on industrial goods.

In comparison with the base case, the main effect of imposing constant returns to scale upon the model is that as industrial output rises firms are no longer operating in the rising portion of their cost curves. With greater efficiency and lower costs, the price of industrial goods falls, so does employment in private industry. The real incomes of all the employed groups rise, that of the capitalists by one-third, and those of the agriculturalists, the civil servants, and the industrial workers by one-tenth. The unemployed, who have increased in numbers, must share the gifts from the employed more widely, so their income per capita falls by approximately one-twentieth. The assumption of constant returns to scale is thus not a wholly benevolent one, for although those fortunate enough to have employment do benefit, an increasing number are unemployed.

Since, with the Cobb-Douglas function, the productivity of the inputs to industrial production is undiminished with changes in output, it is possible that output in the Northeast could, under this formulation, rise more rapidly. If the firms in the Northeast were to increase their fraction of the industrial goods consumed within the region by 5 percent each year, by 1980 they would be supplying 90.7 percent of the total demand. Unemployment would have ceased in that year, and the incomes of all the groups in the population would have risen substantially. At lesser rates of growth of industrial production, unemployment would exist, even though the productivity of additional

workers, if employed and if provided with capital equipment, would be as high as that of those already employed.

THE EFFECTS OF VARYING THE STRUCTURE OF THE MODEL -- DIFFERENT PRODUCTION FUNCTION IN AGRICULTURE: CASES VPA-A THROUGH -C

The other familiar production function is the CES, or Constant Elasticity of Substitution function [465] which we now apply to the production of agricultural goods in the traditional sector. Both the Cobb-Douglas and the CES functions permit the substitution of the relatively abundant factor, labor, for the relatively scarce factor, land; but because we believe that the possibility of substituting labor for land is not very great -- certainly not as great as is implied by the Cobb-Douglas function -- we prefer the CES function for agriculture.

In its basic form the CES function is stated as follows:

$$q = \alpha[\delta K^{-\rho} + (1-\delta)L^{-\rho}] \frac{\nu}{\rho} .$$

Where q is output, α is a parameter relating inputs to output, δ is a parameter determining the division of factor income, ν is a measure of the returns to scale and ρ represents the possibilities for substitution of one factor of production for the other. The two factors of production are labor (L) and land (K); the amount of land under cultivation is calculated elsewhere, and the amount of labor will be assumed to be equal to the amounts already employed on the land under the earlier formulation plus at least a part of those unable to obtain employment in industry.

It will take several additional equations to express this relationship between inputs and outputs in agriculture, and to fit it into the rest of the model.

The first is the CES production function, written in the appropriate symbols:

$$\text{OAS}_i = (\text{CØASC5})\left[(\text{CØASC6})(\text{KUA}_i)^{(\text{CØASC7})} + (1-\text{CØASC6})(\text{PEA}_i)^{(\text{CØASC7})}\right]^{(\text{CØASC8})} \tag{10A}$$

where

ØAS = Øutput of the Agricultural Sector, units per year,

KUA = C(K)apital Utilized in Agricultural production, rai of land,

PEA = Population Employed in Agriculture, number of persons,

CØASC5, 6, 7, 8 = Coefficients used in calculating the Øutput of the Agricultural Sector, Constants (equivalent to α, δ, ρ, and $\frac{\nu}{\rho}$ respectively), various dimensions.

We shall assume constant returns to scale, so that ν will be equal to unity and CØASC8 to the reciprocal of CØASC7.

A second equation is necessitated by the "opening" of the model to permit changes in the population employed in the traditional sector. So long as agricultural inputs were combined in fixed proportion and land was the limiting factor, the size of the farm population was determined by the quantity of arable land. In Eq. (10A), however, factor proportions are not fixed, so some mechanism is needed by which the agricultural population can adjust to changes in economic conditions. The relationship we use is the one below:

$$\text{PEA}_i = \text{PEA}_{i-1} + (\text{PEAC1})(\text{PU}_{i-1}) - (\text{PEAC2})(\text{WEI}_{i-1} - \text{WEA}_{i-1}) \tag{9A}$$

where

PEA = Population Employed in Agriculture, number of persons,

PU = Population Unemployed, number of persons,

WEI = Annual Wage of those Employed in private Industry, baht per person per year,

WEA = Annual Wage of those Employed in Agriculture, baht per person per year, and

PEAC1, 2 = Coefficients determining the changes in the Population Employed in Agriculture, Constants, various dimensions.

The population employed in agriculture, at any instant, is thus directly proportional to the population unemployed in a previous instant, and inversely to the previous difference between urban and rural incomes. *Equation* (9A) states that some fraction of those who were previously unemployed will begin to work on the farms, and that they may be offset by another fraction which will be enticed from the farms by higher wages existing in industry.

In simulating the effects of variable proportions in agricultural production, we tried different values for the parameters CØASC6, 7, and 8, and PEAC1 and 2. Assuming that the population movements in and out of agriculture in 1960 were in balance, PEAC1 and PEAC2 had to be in the proportion of 1:107.1; in the simulations we tried three values of PEAC1 equal successively to 0.1, 0.05, and 0.01, and set PEAC2 accordingly. On the assumptions (1) that labor and land contribute equally in agriculture, CØASC6 was assigned a value of 0.5; (2) that the elasticity of factor substitution in agriculture is considerably less than unity,* CØASC7 (which is inversely proportional to the substitution elasticity) was assigned alternative values of -2.0 and -3.0; and (3) that there are constant returns to scale in production, CØASC8 was made equal to the reciprocal of CØASC7.

It turned out that the crucial relationship was that expressing population mobility, not that expressing factor substitutability. Choosing various values for the parameters PEAC1 and 2, while keeping

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*For industry, the elasticity of substitution in CFS production functions has been found to lie in the range 0.6 to 0.9 [455, p. 38]; for agriculture we should expect it to be less. An elasticity of 0.25 would be equivalent to a value of CØASC7 of -3.0.

those for CØASC5-8 fixed, caused quite large differences in the behavior of the system; whereas choosing various values for CØASC5-8, while keeping those for PEAC1 and 2 fixed, caused little noticeable difference. Surprisingly, the responses of the model to changes in the economic factors affecting agriculture are great, but responses to changes in the technological factor are minute.

Although the magnitude of the effects of changes in the economic factors might not have been predicted, their direction might have been. The more burdensome the unemployment -- that is, the larger the value of PEAC1 -- the more people added their labor to cultivation: when the value of PEAC1 was equal to 0.01, the population employed in agriculture in 1980 was 11,228,000 persons (see Table 22); when it was 0.05, the population was 12,997,000; and when 0.1, it was 13,337,000.

The major effect of variations in the value of PEAC1 was on unemployment. In the first of the cases above, over two million individuals were without employment; in the third case, only three hundred thousand. In the first case, the fraction of the total industrial labor force employed (FAEI) was 0.34; in the third, 0.74. Consequently, wages in industry were lower in the first case than in the third, and output in industry was higher in the first than in the third, as entrepreneurs employed more of the cheaper input. Finally, the marginal product of each worker when employed in agriculture was less than that when employed in industry. As a consequence, overall output (RØ) in the region was lower in the third case than the first, for the additional output from agriculture failed to compensate for the loss of output from industry.

If the comparison is made between the first and second variations, however, we find that total output in the region differ by only 2 percent -- the increase in output of the 340,000 workers absorbed by the rural sector nearly matching the loss in output of the 100,000 released by the industrial sector. The overall differences between the two cases are in unemployment (in the first variation there are 240,000 [340,000 - 100,000] fewer unemployed) and in the distribution of

Table 22

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN FACTOR PROPORTIONS IN AGRICULTURE

Variables		Values					
Definition	Symbol	Base Case	VPA-A	VPA-B	VPA-C		
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Factor sub. in ag.	CØASC 7	-	2.0	→	→		
Movement to ag.	PEAC 1	-	0.1	0.005	0.001		
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→	→		
In agriculture	PEA	12044	13337	12997	11228		
In government	PEG	1757	→	→	→		
Entrepreneurs	PØKI	27	→	→	→		
In industry	PEI	1175	973	1075	1180		
Unemployed	PU	1436	344	583	2246		
Fraction employed	FAEI	0.45	0.74	0.65	0.34		
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	15004	14626	12664		
Ind. output (000,000)	ØIS	488	453	472	487		
Capital stock (000,000)	KI	11364	11403	11408	11276		
Efficiency	EFFI	0.755	0.827	0.787	0.756		
Number of firms	NFI	26700	→	→	→		
Price of ind. goods	DPIØ	5.6	6.3	6.0	5.4		
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1251	1281	1326		
In govt., per capita	TCPCG	5998	5611	5769	6116		
Of capital, per capita	TCPCK	64210	60976	62821	63592		
In ind., per capita	TCPCI	1689	2026	1855	1649		
Unemployed, per capita	TCPCU	423	492	475	385		
Average per capita	TCPC	1866	1843	1870	1834		
Total income (000,000)	TC	30686	30303	30738	30141		
Output per capita	RØPC	1099	1075	1066	970		
Total output (000,000)	RØ	16750	17663	17520	15952		
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→	→		
Ag. inv. (000,000)	EGA	1330	→	→	→		
Ind. inv. (000,000)	EGKI	1227	→	→	→		

income among the sectors (the higher the employment in the sector, the lower the per capita real income). We can conclude that if land can be cultivated more intensively -- in other words, if factors can be used in variable proportions in agriculture -- and if there is substantial unemployment within the society, it is worthwhile (in both senses of increasing total employment and total output) to keep labor on the farm. "Substantial," according to our model, would mean more than 30 percent of the potential urban labor force unemployed (equivalent to FAEI being less than 0.7). But if there is not "substantial" unemployment, reducing unemployment still further by encouraging or forcing a return to the land will reduce total output, and agriculture's share as well. At this stage, the society can produce more by keeping some of its resources idle.

THE EFFECTS OF VARYING THE STRUCTURE OF THE MODEL -- DIFFERENT LABOR SUPPLY SCHEDULE: CASE WSUB

The third structural change will be that of the supply schedule of labor. Originally we assumed that the wage rate in private industry would fall toward a minimum somewhat greater than the wage in the agricultural sector, as the fraction of the labor force failing to find employment rose. Under no circumstances would the industrial wage fall below the agricultural wage, even though unemployment were rife. This assumption is questionable, for with very high rates of unemployment, it is conceivable that the industrial wage might fall below the agricultural. Since there is no alternative employment for those who fail to find it in industry, the unemployed workers may be willing to accept any wage above that necessary to provide subsistence. In this case, the subsistence wage rather than the average wage in agriculture would be the floor.

Assuming a value of 300 baht per person per year for WSUB, we can formulate a new supply function for industrial labor merely by substituting the subsistence wage, WGSUB, for the agricultural wage, in the supply function, Eq. (34).

The new equation would be written:

$$WEI_i = (WGSUB)(\underline{1} + \frac{WDFC}{\underline{1} + FAEI_i}).$$

WDFC will have to be recalculated so that the new supply schedule will pass through the point appropriate for 1960, when the average wage in industry was equal to 1550 baht per person per year and the proportion of the labor force employed was equal to 0.7926.

With this new relationship between the wage rate and the fraction unemployed in private industry, we will expect unemployment to be less pervasive, and wages, and consequently costs and prices, to be lower. Total output will presumably increase, but changes in the distribution of income cannot be predicted. To see how the total benefits in the Northeast are distributed, we must compare the behavior of the model with this new supply function to the base case.

The results of the simulation are summarized in Table 23, case WSUB. Industrial output, employment, and capital stock do rise by 12.1 percent, 37.4 percent, and 1.1 percent, respectively, above the base case in 1980; and wages and the price of industrial goods do fall by 26.2 percent and 8.6 percent. The lowest wage reached in industry is 896 baht per year, in 1973; at that point the average wage in agriculture is 919. By 1980 the two are nearly equal (981 vs. 986), and at the end of the simulation, in 1985, the wage in industry exceeds that in agriculture (1264 vs. 1036 baht per year) once again.

Because of the fall in the price of industrial goods, those with fixed income -- agricultural workers and civil servants -- gain; and because of the reduction in unemployment, charitable donations per recipient rise. The average wage of industrial employees falls; but the rise in employment is greater than the fall in wages, so the total income of the group is greater. Entrepreneurial incomes rise too, in roughly the same proportions as incomes of all the other groups.

There is no redistribution among socio-economic groups. Only within the group of industrial workers is there any redistribution,

Table 23

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN THE LABOR SUPPLY SCHEDULE (CASE WSUB) AND WITH CONDITIONS APPROPRIATE FOR MAXIMUM EMPLOYMENT (CASE XEMP)

Variables		Values					
Definition	Symbol	Base Case	WSUB	XEMP			
INPUTS - 1960							
RATES OF GROWTH							
Population	MXRGP						
Decline in R.G.P.	NDRGP						
Cultivation	KUAC 2						
Productivity, ag.	CØAS 2						
Local supply	FIØNC 2						
Productivity, ind.	CØIC 3						
	CØIC 5						
PROPENSITIES							
Est. new firms	NFEKC						
To invest	APIKC						
Price elasticity	PEAAC						
Income elasticity	YEAAC						
Wage floor	WEI min	1.2 (WEA)	300	→			
GOVERNMENT POLICIES							
Growth of ag. inv.	EGAC						
Initial ag. inv.	EGAC 1						
Growth of ind. inv.	EGKIC						
Initial ind. inv.	EGKIC 1						
Est. new firms	NFEGC						
Growth of civil serv.	INPEG						
Growth of salaries	IWEGC						
Family planning	IDRGIP						
OUTPUTS - 1980							
OCCUPATIONAL GROUPS (000)							
Total population	PT	16438	→	→			
In agriculture	PEA	12044	→	13287			
In government	PEG	1757	→	→			
Entrepreneurs	PØKI	27	→	→			
In industry	PEI	1175	1615	1050			
Unemployed	PU	1436	995	318			
Fraction employed	FAEI	0.45	0.619	0.768			
PRODUCTION, ETC.							
Ag. output (000)	ØAS	13565	→	14733			
Ind. output (000,000)	ØIS	488	547	590			
Capital stock (000,000)	KI	11364	11496	11804			
Efficiency	EFFI	0.755	0.640	1.0			
Number of firms	NFI	26700	→	→			
Price of ind. goods	DPIØ	5.6	5.12	4.92			
Wage in industry		1328	981	1417			
INCOMES (baht per year)							
In ag., per capita	TCPCA	1316	1402	1390			
In govt., per capita	TCPCG	5998	6393	6619			
Of capital, per capita	TCPCK	64210	72307	86919			
In ind., per capita	TCPCI	1689	1305	1951			
Unemployed, per capita	TCPCU	423	472	545			
Average per capita	TCPC	1866	1985	2107			
Total income (000,000)	TC	30686	32632	34639			
Output per capita	RØPC	1019	1055	1118			
Total output (000,000)	RØ	16750	17341	18379			
GOVERNMENT EXPENDITURES							
Total (000,000)	EG	10433	→	→			
Ag. inv. (000,000)	EGA	1335	→	→			
Ind. inv. (000,000)	EGKI	1227	→	→			

with many more employees sharing an only slightly larger wages fund. Those who were initially employed in industry suffer, to the benefit of those who are subsequently added. In the face of substantial unemployment, the resistence of organized industrial labor to a reduction in wages is quite in its own interest, although against the interest of every other group in the society. In his own self-interest, each person is justified in recommending that everyone else's income should be flexible downward while his should be fixed.

THE COMBINED EFFECTS OF VARYING THE STRUCTURE OF THE MODEL

Changing the structure of the model, even when it is unaccompanied by any changes in parameter values, will produce different bahvior for all but one point in the output set. Changing the structure is therefore nearly as complex in its effects as changing both the structure and the values of the inputs. It is not necessary to run additional cases merely to show how the model would behave when both types of changes were made. However, it may be interesting to impose on the model several changes all of whose likely effects would be to reduce unemployment in the region. If we were to assume variable coefficients in production in agriculture, a labor supply schedule with a floor set by subsistence rather than the agricultural wage, and a production function in industry with constant returns to scale, we would have chosen the model that would be most conducive to full employment. Each of these alterations to the base case has already been made separately: Table 22 revealed what happens when the assumption of fixed coefficients in agriculture was relaxed; Table 23 (case WSUB), when the assumption of an industrial wage rate always above that in agriculture was relaxed; and the analysis on pp. 200 through 203, when the assumption of constant returns to scale is imposed. But we have not as yet tried to make any joint alterations; we have not as yet made two or more changes simultaneously. This we now do hoping that it will give us indications both of what might happen if our original model were modified substantially, and of how the economy of the Northeast might develop if the relationships were the most favorable.

That output, employment, and incomes rise (under conditions of factor substitution in agriculture, and flexible wages and constant returns to scale in industry) is predictable, for the first and third conditions increase the average productivity of labor in agriculture and industry, respectively, and the second helps to allocate labor more effectively between the two sectors. What is not predictable is the relative contribution that each of these changes makes. Least consequential of the three is the assumption of constant returns to scale; equally consequential are the other two, although the consequences differ. If the industrial wage is made more flexible, then industrial and total output rise most; if agricultural technology is made more flexible, then employment rises most. If output is to be maximized, wages should be flexible. Computer runs incorporating all these changes are summarized in Table 23 (p. 210). The first column is the base case; the second, the case with flexible wages in industry (WSUB); and the third, the case with flexible wages in industry plus variable proportions in agricultural production and constant returns to scale in industrial production (XEMP). Output is the highest and unemployment the lowest in the last case; compared with the base case in 1980, agricultural production rises by 9 percent and industrial production by 20 percent. Employment is 10 percent higher in agriculture although 10 percent lower in industry; unemployment drops from 1,436,000 to 318,000 persons. Everyone's real income is higher: that of agricultural and industrial laborers because of lower prices, and that of the entrepreneurs because of greater demand. Making the economy more flexible brings universal benefits.

SUMMARY

We can now summarize what we have learned about the stability of the system. Our general conclusion is that most of the outputs of the system are stable, changing in lesser proportion than changes in inputs. The system seems to absorb shocks and to dampen fluctuations. If we compare the relative changes in the majority of the variables with

changes in parameter values -- in other words if we calculate the elasticities of response -- we find that outputs are generally unresponsive to changes in inputs.

There are two qualifications to this statement. The first is that we have assumed that the system's responses are in the same proportions to changes in inputs over the entire possible set of changes. It is conceivable that the system could absorb minor shocks or dampen small changes in parameter values but would break down or exhibit contrary behavior under large shocks and with large changes in parameter values. We did not observe any such behavior, but we cannot exclude its possibility.

The second qualification relates to variables whose behavior does not conform to the general pattern. These are the residual elements in the system, such as unemployment in industry, incomes of entrepreneurs, and the budget deficit of the Thai government. Were these residual elements of minor interest, we should have no worries; but the level of unemployment, the wages of entrepreneurs, and the deficit in the budget are all of great political importance. The elements of greatest political importance seems to be those whose values fluctuate most widely: in our various simulations the level of unemployment, as of 1980, varied from 20,000 to 2,000,000 individuals; the incomes of entrepreneurs, from 10,000 to 100,000 baht per year; and, as we shall see in the next section, the deficit of the government in its operations in the Northeast, from 2 to 20 billion baht per year. In all these cases the differences in the stress upon the society under the best and the worst conditions would be vast. Our model appears to be very stable so far as the explicit economic variables are concerned, and very unstable so far as the implicit political variables are concerned.

XI. THE EFFECTS OF ALTERNATIVE GOVERNMENT POLICIES

There are many decisions regarding output, consumption, and employment incorporated in the model, but with the exception of one set they are collective expressions, aggregating a large number of independent choices by different individuals. The exceptional set is the monolithic decisions of government: how much to spend in the Northeast and how to allocate the expenditures among the competing claims. These are decisions made by a single authority with a wider degree of freedom than the householder (who must budget strictly), than the farmer (whose land and knowledge are limited), or than the entrepreneur (whose equipment is immobile). Only the government can substantially alter its expenditures on this or that category from one year to the next. Because they are flexible, government expenditures will be considered separately.

But there are other reasons for focusing on government policies. First of all, government policy is formulated in Bangkok: even today, when the Northeast is in a state of emergency, the major political decisions are still made in the capital [452]. Furthermore, the data underlying these decisions are often fragmentary or inaccurate, and delayed in transit.

The public policy-maker does not directly or immediately feel the impact of his policy: he is not obliged to study under the teachers he hires, nor use the roads he builds, nor obey the police he sends out. Civil servants make decisions for others with various aims in mind. The civil servant wishes not only to increase the public welfare but also to advance himself in the bureaucracy. He holds certain economic, political, and social goals for the populace and similar but not necessarily consistent goals for himself. Personal advancement, organizational success, and national progress contend for his favor.

As a result of all these factors, government expenditures, unlike personal consumption, are not easily predictable and may change radically from one period to the next. We shall try to determine the

consequences of some rather large changes; the simulation model is useful in this task for it is able to determine the ultimate effects of all the interactions among the specified economic variables. It determines not only the first order effects but also those of the second, third, and subsequent orders. The model is also useful because the effects of radical changes are themselves likely to be radical: one needs to know more than just the signs of the partial derivatives of a simultaneous differential equation system. Politicians may be better able to determine the possible outcomes of substantial changes in government policy, but their biases are implicit and their predictions intuitive, whereas those of the model are explicit, numeric, and reproducible.

In trying to determine the effects of different government policies, we divide the instruments into three categories: the levying of taxes, the expending of funds, and the changing of institutions.

THE EFFECTS OF VARIATIONS IN PROFITS TAX

With the Northeast capable of contributing such a small proportion of the funds the government will probably expend in the region, the latitude for tax collection is not very great. Even if taxes are increased substantially, the budget for the region will still very likely be in deficit; the best the government can do is reduce somewhat the gap between receipts and expenditures. It may be worthwhile, though, to investigate the effects of changing one particular tax, that on the profits of entrepreneurs.

Individually, entrepreneurs are wealthier than the members of the other groups; collectively they offer a moderately large potential source of revenue. Let us determine the effect of a change in their taxes upon their incomes, investment, and the rate of output of their firms, as well as upon employment and the other elements of the economy of the Northeast. We estimated that entrepreneurs individually paid 2.2 percent of their income in taxes in 1960. What if this figure were doubled? Cut in half?

Because taxes from entrepreneurs are one of the four main direct sources of the government's income in the Northeast, the change in the government's revenues is proportionately much greater than the change in entrepreneurial income. If the tax rate on entrepreneurs is increased from 2.2 percent to 3.3 percent of their total income, the revenues of the government in 1980 increase by 9.8 percent, from 136 million baht to 149 million. At the higher level of taxation, entrepreneurs would be providing 39 million, industrial employees 34 million, civil servants 51 million, and farmers 24 million baht per year. If the tax on entrepreneurs were increased yet again from 3.3 percent to 4.4 percent, the increase in government revenues would be 9.3 percent; the rate of increase is less than proportional because of the progressively greater fall in entrepreneurial incomes at higher and higher rates of tax.

The primary effect of changing the tax rate is to change entrepreneurs' disposable income. The secondary effects of changing the tax rate on entrepreneurs are negligible, except for their investment in capital equipment. As the tax rate rises, the disposable income of entrepreneurs falls. Due to the combination of the increase in taxes, the reduction in entrepreneurial income, and the greater than unit elasticity of entrepreneurs' expenditures on industrial goods, proportionately less funds remain for investment. The reduction in total investment is not as great as the reduction in income, however, because of the government's additions to industrial capital; in the case in which the tax rate rises from 2.2 percent to 3.3 percent, the capital stock of industry falls by 0.3 percent from the base case in 1980.

The only other noticeable effects are slight reductions in output and employment in industry, both of the order of 0.1 percent. Whether total investment and output in industry rises or falls with changes in the tax on entrepreneurs depends upon the level of income of the average entrepreneur and upon the relative propensities to save of entrepreneurs and of the government. According to our model and to the values that we have chosen for the parameters, the government

would have to invest in industry and agriculture somewhat less than half of each additional baht collected as taxes, in order to compensate for the loss of private investment.

THE EFFECTS OF VARYING THE "RICE PREMIUM"

In 1960 the largest source of government revenue in the Northeast was derived from the export of rice. The government purchased some of the surplus of the region at a price well below that existing in foreign markets, sold it at the world price, and kept the difference. Some economists [119] have suggested that the government would be advised to raise the domestic price of rice, thereby increasing the income of farmers and also perhaps total production, if output is responsive to price increases. From the evidence, we believe that the composition of agricultural output would shift in accordance with shifts in the relative prices of farm commodities [see 382], but not that total output would change (see Section I). We therefore assume that agricultural output is a function of the amount of land under cultivation and is independent of agricultural prices. We can, however, determine the income and expenditure effects of increasing the price the farmer receives for his produce. Let us simulate two cases: the first in which the domestic price of agricultural goods is increased from 875 baht per unit (the value in 1960) to 900 baht per unit, and the second in which it is reduced to 850 baht per unit, keeping all of the other conditions the same as in the base case.

These changes of 2.86 percent in the price of agricultural products are assumed to take place in 1970. The effects of raising or lowering the price are symmetrical; if we consider the rise in price, then we find an immediate rise in the value of agricultural production in proportion to the rise in price. Incomes in agriculture rise by a similar fraction, and this is distributed as increases in purchase of industrial and agricultural goods, in greater and lesser proportions respectively. As the price of agricultural goods remains unaltered, the increase in demand for agricultural goods results simply in an increase in their purchase, but the increase in demand for industrial goods is reflected

in an increase in their price as well. The increase in the price of industrial goods is 2 percent, nearly equal to the stipulated rise in agricultural goods; thus, relative prices change very little.

As the wage rate in industry is tied to that in agriculture, it too rises, making labor more expensive to entrepreneurs, who respond by reducing employment by 1 percent and output by 0.3 percent. The increase in the price of industrial goods more than compensates for the rise in wage rates, so that entrepreneurs receive more income and invest more; there is thus some substitution of capital for labor in industrial production.

With both prices and incomes rising, no group in society benefits substantially. The real income of agricultural and industrial workers rises very slightly, while that of civil servants, who have fixed money incomes, falls slightly. There is, to be sure, a very meager shift in the distribution of income from the higher income to the lower income groups, but it is hardly noticeable in the model and probably would not be in the real world. The agricultural sector, which was presumably meant to benefit greatly from the increase in agricultural prices fails to receive much benefit at all; in contrast to the results of the analysis of Heymann et al. [119], the reduction in the "rice premium" has not substantially benefited its grower.

THE EFFECTS OF CHANGES IN EMPLOYMENT AND WAGES OF GOVERNMENT: CASES IWEG-A AND -B, AND INPEG-A AND -B

The second type of government policy is that relating to expenditures. To be determined are the overall level of expenditures and the proportions spent upon various activities. Government investment can be directed either to agriculture or industry; current expenditures to increasing government employment or raising wages. We devise some alternative programs of government expenditures to determine how sensitive the model is to their absolute and relative changes. The first set of runs is devoted to altering the level of expenditures on the current operations of government, which in our model are designated as wages paid to civil servants. In two cases we alter the rate at

which salaries of civil servants increase. In the base case, salaries of civil servants were assumed to rise annually at a rate of 3 percent; in the two variations we assume (1) no annual rise, and (2) an annual rise of 5 percent.

The first observation is that the total expenditures of government in the Northeast diminish by approximately 30 percent over the base case when civil servants' salaries remain constant (see Table 24, cases IWEG-A and -B). In the base case (1980), 7.8 thousand million baht out of total expenditures of 10.4 thousand million baht go to pay civil servants; when they are not favored with annual increases, total wages are 4.3 thousand million baht. When the rate of increase of civil servants' salaries is 5 percent per year, total expenditures rise dramatically from 10.4 to 14.3 thousand million baht.

Increasing the pay scales of civil servants results in more than proportionate increases in industrial output and employment in private industry and less than proportionate increases in industrial capacity and real output in the Northeast. Since output rises slower than inputs, cost per unit of output in industry also rises, so that the average productivity of the factors of production falls. But although employment and output increase, unemployment still remains substantial, nearly one-half of the industrial labor force being unemployed at the highest rate of growth of civil servants' salaries.

If the effects of raising the salaries of civil servants are primarily to increase industrial output and prices, the effect of increasing the numbers employed by government is to reduce unemployment. The two variations that were carried out on this theme (see cases INPEG-A and -B in Table 24) were to compare annual rates of increase of government employment of 5 percent and 15 percent with the annual rate of 10 percent in the base case. Doubling the rate of growth of employment from 5 percent to 10 percent per year nearly trebles the total number of civil servants by the year 1980. The totals are: 646,000 government employees, earning 2.9 thousand million baht per year, at an annual rate of growth of 5 percent; and 1,757,000,

Table 24

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN GOVERNMENT EXPENDITURES
ON CURRENT OPERATIONS

Variables		Values				
Definition	Symbol	Base Case	IWEG-A	IWEG-B	INPEG-A	INPEG-B
INPUTS - 1960						
RATES OF GROWTH						
Population	MXRGP					
Decline in R.G.P.	NDRGP					
Cultivation	KUAC 2					
Productivity, ag.	CØAS 2					
Local supply	FIØNC 2					
Productivity, ind.	CØIC 3					
	CØIC 5					
PROPENSITIES						
Est. new firms	NFEKC					
To invest	APIKC					
Price elasticity	PEAAC					
Income elasticity	YEAAC					
GOVERNMENT POLICIES						
Growth of ag. inv.	EGAC					
Initial ag. inv.	EGAC 1					
Growth of ind. inv.	EGKIC					
Initial ind. inv.	EGKIC 1					
Est. new firms	NFEGC					
Growth of civil serv.	INPEG		→	→	0.05	0.15
Growth of salaries	IWEGC		0.00	0.05	0.03	→
Family planning	IDRGIP					
OUTPUTS - 1980[a]						
OCCUPATIONAL GROUPS (000)						
Total population	PT	16438	→	→	→	14149
In agriculture	PEA	12044	→	→	→	10960
In government	PEG	1757	→	→	646	2256
Entrepreneurs	PØKI	27	→	→	→	21
In industry	PEI	1175	998	1354	966	773
Unemployed	PU	1436	1612	1257	2756	139
Fraction employed	FAEI	0.45	0.38	0.52	0.26	0.85
PRODUCTION, ETC.						
Ag. output (000)	ØAS	13565	→	→	→	11742
Ind. output (000,000)	ØIS	488	454	517	446	312
Capital stock (000,000)	KI	11364	11134	11595	11061	7548
Efficiency	EFFI	0.755	0.827	0.697	0.843	0.853
Number of firms	NFI	26700	→	→	→	20807
Price of ind. goods	DPIØ	5.6	4.9	6.3	4.7	8.2
INCOMES (baht per year)						
In ag., per capita	TCPCA	1316	1418	1230	1443	1042
In govt., per capita	TCPCG	5998	3548	8290	6725	4142
Of capital, per capita	TCPCK	64210	57060	71180	55190	59680
In ind., per capita	TCPCI	1689	1770	1625	1764	1940
Unemployed, per capita	TCPCU	423	396	754	358	429
Average per capita	TCPC	1866	1662	2068	1577	1667
Total income (000,000)	TC	30686	27239	33980	25899	23583
Output per capita	RØPC	1019	1000	1039	996	947
Total output (000,000)	RØ	16750	16410	17040	16330	13400
GOVERNMENT EXPENDITURES						
Total (000,000)	EG	10433	6879	14307	5454	10255
Ag. inv. (000,000)	EGA	1335	→	→	→	807
Ind. inv. (000,000)	EGKI	1227	→	→	→	744

Note:

[a]For case INPEG-B, outputs are as of 1975.

earning 7.9 thousand million baht per year, at an annual rate of growth of 10 percent per year.

With many more inhabitants employed by the government, there are fewer seeking employment in industry -- 2,600,000 when government employment is increasing at 10 percent per year and 3,700,000 when it is increasing at 5 percent per year. Of the smaller total, 45 percent find employment in private business; of the larger total, only 26 percent find such employment.

Note the slightness of the change induced in private industry as a result of the large change in the allocation of urban labor. According to the model, the output of agriculture was not likely to change, but even the output of private industry rose by only 10 percent with the great increase in income provided by the appointment of large numbers of civil servants. When 1,757,000 people are supported by the government, entrepreneurs choose to produce 488,000 units per year. When only 646,000 people are supported by the government, entrepreneurs choose to produce 446,000 units per year. The great decrease in demand does not elicit an equally great decrease in output: the main and almost single effect of reducing the number of civil servants is to increase unemployment.

THE EFFECTS OF REALLOCATING GOVERNMENT INVESTMENT AMONG AGRICULTURE AND INDUSTRY: CASES EGA-A THROUGH -D

Having examined the effects of changes in government expenditures on its current activities, we now examine the effects of changes in government expenditures on investment. In the model, government investment is divided into two categories, agricultural and industrial. Investment in agriculture increases the stock of tillable land, which in turn yields increases in agricultural output and the population employed therein. Government investment in industry results in an increase in capital stock, which in turn yields an increase in output and, to a lesser extent, a substitution of capital for labor. Although the government makes these investments, it is the cultivators of the

land and the owners of capital equipment who, according to our model, appropriate the income derived from the investment.

Our procedure in estimating the effects of changes in government investment between agriculture and industry is to hold the total level of government expenditure constant and to vary the amounts invested in the two sectors. In the base case, annual investments in agriculture and industry increased at the rate of 10 percent per year from initial values in 1960 of 180 million baht in agriculture and 166 million baht in industry. In two variations, we altered the values of the two growth parameters, EGAC and EGKIC, so that the former was larger than the latter throughout, and in two other cases so that the latter was larger than the former. In the first variation the annual rate of increase of government expenditures in agriculture was 10.9 percent per year and in the second variation 11.8 percent per year; in industry in the first and second variations it was 9 percent and 8 percent per year respectively. In the third and fourth variations, the annual rates of growth of government investment were reversed.

Increasing investment in agriculture and proportionately reducing it in industry yields a less-than-proportionate increase in agricultural output and in the population supported by agriculture. The capital stock of industry and industrial output fall, also less than proportionately. In 1980 for example (see Table 25), in comparison with the results of the base case we find that industrial output has fallen by approximately 4 percent in the first variation, more than twice the increase obtained in agricultural output. What is remarkable is that the population employed in private industry hardly falls at all, by a mere 0.3 percent. When entrepreneurs are faced with an increase in demand following higher incomes in agriculture, and are operating at close to full capacity, they substitute labor for capital in manufacturing. The increase in demand for industrial goods leads to a rise in their price, from 5.6 to 5.8 baht per unit, but the reduction in output produces an increase in efficiency, from 0.755 to 0.794. Since employment in agriculture has risen considerably (by 135,000 persons)

Table 25

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN GOVERNMENT EXPENDITURES ON INVESTMENT

Variables		Values				
Definition	Symbol	Base Case	EGA-A	EGA-B	EGA-C	EGA-D
INPUTS - 1960						
RATES OF GROWTH						
Population	MXRGP					
Decline in R.G.P.	NDRGP					
Cultivation	KUAC 2					
Productivity, ag.	CØAS 2					
Local supply	FIØNC 2					
Productivity, ind.	CØIC 3					
	CØIC 5					
PROPENSITIES						
Est. new firms	NFEKC					
To invest	APIKC					
Price elasticity	PEAAC					
Income elasticity	YEAAC					
GOVERNMENT POLICIES						
Growth of ag. inv.	EGAC	0.100	0.090	0.109	0.080	0.118
Initial ag. inv. (000)	EGAC 1	180000	→	→	→	→
Growth of ind. inv.	EGKIC	0.100	0.109	0.090	0.118	0.080
Initial ind. inv. (000)	EGKIC 1	166000	→	→	→	→
Est. new firms	NFEGC					
Growth of civil serv.	INPEG					
Growth of salaries	IWEGC					
Family planning	IDRGIP					
OUTPUTS - 1980						
OCCUPATIONAL GROUPS (000)						
Total population	PT	16438	→	→	→	→
In agriculture	PEA	12044	11915	12178	11803	12333
In government	PEG	1757	→	→	→	→
Entrepreneurs	PØKI	27	→	→	→	→
In industry	PEI	1175	1177	1171	1178	1166
Unemployed	PU	1436	1563	1305	1673	1156
Fraction employed	FAEI	0.45	0.43	0.47	0.41	0.50
PRODUCTION, ETC.						
Ag. output (000)	ØAS	13565	13420	13717	13295	13891
Ind. output (000,000)	ØIS	488	505	469	524	450
Capital stock (000,000)	KI	11364	12494	10282	13798	9356
Efficiency	EFFI	0.755	0.720	0.794	0.694	0.835
Number of firms	NFI	26700	→	→	→	→
Price of ind. goods	DP1Ø	5.6	5.4	5.8	5.2	6.1
INCOMES (baht per year)						
In ag., per capita	TCPCA	1316	1342	1287	1369	1259
In govt., per capita	TCPCG	5998	6039	5838	6276	5684
Of capital, per capita	TCPCK	64210	66490	61750	68220	59530
In ind., per capita	TCPCI	1689	1707	1660	1735	1643
Unemployed, per capita	TCPCU	423	423	422	433	423
Average per capita	TCPC	1866	1902	1878	1938	1797
Total income (000,000)	TC	30686	31244	30853	31827	29525
Output per capita	RØPC	1019	1021	1016	1024	1012
Total output (000,000)	RØ	16748	16780	16700	16850	16630
GOVERNMENT EXPENDITURES						
Total (000,000)	EG	10433	10434	10473	10526	10605
Ag. inv. (000,000)	EGA	1330	1089	1592	892	1906
Ind. inv. (000,000)	EGKI	1227	1468	1004	1758	822

and employment in industry has fallen by very little (only 4,000 persons), unemployment has been reduced by the difference between the two. In the industrial labor force, 47 percent rather than 45 percent are now employed.

The overall effect of increasing the proportion of government investment going to agriculture is that real output in the region diminishes slightly, by approximately 0.2 percent from the base case. Shifting investment to agriculture may be effective in generating employment; it is ineffective in raising output.

Substitution in the opposite direction -- investing in industry rather than in agriculture -- produces the opposite effects. The capital stock in industry rises, as does industrial output; output, employment and income in agriculture fall, and with the fall in demand there is a fall in the price of industrial goods; entrepreneurs increase employment slightly (by 0.2 percent over the base case) so as to use capital equipment more intensively; the fall in agricultural output is more than compensated for by rising industrial output, so that total output rises by 0.2 percent; and finally, unemployment rises by 170,000 persons. Thus, shifting government investment from agriculture to industry yields a meager increase in total output and a substantial increase in unemployment.

There are three qualifications to these generalizations, one arising out of calculating output on the basis of prices as they were in 1960. Had we used prices of 1980, when the price of industrial goods had fallen relative to that of agricultural goods, we would have found that total output rose rather than fell slightly when agricultural investment was emphasized, and fell rather than rose slightly when industrial investment was emphasized. The conclusion as to the direction of changes in total output, therefore, depends upon the relative prices used.

The second qualification is that the results of changes in investment depend very much upon the value assigned to IGAC, the coefficient that relates the investment by government (in baht) to the increase in

the stock of arable land (in rai). The value we used was based upon one observation in 1960; higher values would make agricultural investment still more attractive, lower values less so.

The third qualification holds if the inputs in agriculture can be combined in variable proportions, and if the wage rate in industry is held constant. Under these conditions, if investment were shifted from the former sector to the latter, employment in agriculture would fall by no more than the employment in industry would rise. Total output would rise, for investment in industry would appear to be more productive than in agriculture. In the case of agricultural investment being reduced by 10 percent and industrial investment increased by 9 percent (that is, total government investment being unchanged) the increase in total output would be 1.7 percent. This 20 percent reallocation of government investment from agriculture to industry produced a negligible (0.2 percent) increase in total output under conditions of fixed coefficients in agriculture. With variable coefficients however, the preference would be for investment in industry.

The same pattern will emerge when the wage rate in industry is free to fall below that in agriculture. Although making the supply schedule of labor more elastic does result in more labor being employed at a lower level of wages, shifting government investment to or from agriculture yields the same marginal changes. Four cases, similar to those above (cases EGA-A, B, C) in all respects but the labor supply function, gave the same variations from <u>their</u> base (case WSUB on p. 208, Section X). A flexible wage rate in industry, therefore, does not alter the effects of reallocating government investment.

<u>THE EFFECTS OF CHANGES IN THE RATE OF CREATION OF NEW FIRMS: CASES NFEG-A THROUGH -C</u>

The two institutional instruments of government we inserted in the model were encouragement of private business and influence over the rate of growth of population. Through education, licensing, and other programs, the government of Thailand can influence the number

of firms operating in the Northeast. To try to determine the effects of changes in the number of firms, we ran three cases, each with successively higher rates of growth. In the base case the annual rate of growth of firms was 5 percent of the number in existence; in the three variations this was raised to 6 percent, 7 percent, and 8 percent (see Table 26).

The system seems sensitive to changes in the rate of creation of firms in private industry. As the rate rises, employment in private industry steadily increases; unemployment falls; and the total capital stock of industry steadily declines, for total profits are divided among more and more entrepreneurs, each of whom invests less out of a lower income.

Some other variables show reversals in their behavior, as a consequence of first decreases and subsequently increases in unit costs. Initially, as the rate of growth of new firms increases from 5 percent to 6 percent, the price of industrial goods falls, from 5.6 to 5.4 baht per unit in 1980. But this is the minimum price that is realized, for as the rate of growth of new firms rises to 7 percent and 8 percent the price of industrial goods rises again to 5.5 baht per unit.

Just as price reaches a minimum between a 6 percent and 7 percent growth rate of firms, so industrial output, total output, and the efficiency with which resources are used, reach a maximum within the same interval. As the rate of growth of new firms rises from 5 percent to 8 percent, industrial output rises from 488,000 to 508,000 to 510,000 units per year, and then falls to 493,000 units per year. Over the same range, the efficiency with which the resources are combined rises from 0.755 to unity (equivalent to operation at minimum average cost) and then falls off.

As the rate of growth of new firms increases, there are changes in the levels of income (see Table 26). The changes of all the groups but the entrepreneurs are in the same direction as those in output, but of smaller magnitude. Entrepreneurial income and the entrepreneurs' share of total income show a steady decline.

Table 26

CHANGES IN CERTAIN VARIABLES WITH CHANGES IN GOVERNMENT POLICIES TOWARD INSTITUTIONS

V a r i a b l e s		V a l u e s							
Definition	Symbol	Base Case	NFEG-A	NFEG-B	NFEG-C	IGRGP-A	IGRGP-B	IGRGP-C	IGRGP-D
INPUTS - 1960									
RATES OF GROWTH									
Population	MXRGP								
Decline in R.G.P.	NDRGP								
Cultivation	KUAC 2								
Productivity, ag.	CØAS 2								
Local supply	FIØNC 2								
Productivity, ind.	CØIC 3								
	CØIC 5								
PROPENSITIES									
Est. new firms	NFEKC								
To invest	APIKC								
Price elasticity	PEAAC								
Income elasticity	YEAAC								
GOVERNMENT POLICIES									
Additional ag. inv.	EGAC 2	0	→	→	→	→	→	0	10,000,000
Initial ag. inv.	EGAC 1								
Additional ind. inv.	EGKIC 2	0	→	→	→	→	→	10,000,000	0
Initial ind. inv.	EGKIC 1								
Est. new firms	NFEGC	0.05	0.06	0.07	0.08	0.05	→	→	→
Growth of civil serv.	INPEG								
Growth of salaries	IWEGC								
Family planning	IDRGPCI	0	→	→	→	0	10,000,000	0	0
OUTPUTS - 1980									
OCCUPATIONAL GROUPS (000)									
Total population	PT	16438	→	→	→	17137	16464	17137	→
In agriculture	PEA	12044	→	→	→	→	→	→	12062
In government	PEG	1757	→	→	→	→	→	→	→
Entrepreneurs	PØKI	27	33	40	49	27	→	→	→
In industry	PEI	1175	1199	1225	1251	1209	1188	1210	1209
Unemployed	PU	1436	1406	1373	1338	2100	1448	2099	2081
Fraction employed	FAEI	0.45	0.46	0.47	0.48	0.37	0.45	0.37	0.37
PRODUCTION, ETC.									
Ag. output (000)	ØAS	13565	→	→	→	→	→	→	13586
Ind. output (000,000)	ØIS	488	508	510	493	492	489	495	492
Capital stock (000,000)	KI	11364	11301	11223	11127	11324	11326	11463	11324
Efficiency	EFFI	0.755	0.913	1.111	1.341	0.745	0.751	0.740	0.745
Number of firms	NFI	26700	32576	39737	48463	26700	→	→	→
Price of ind. goods	DPIØ	5.6	5.4	5.4	5.5	5.5	5.6	5.5	5.5
INCOMES (baht per year)									
In ag., per capita	TCPCA	1316	1348	1356	1330	1310	1315	1313	1310
In govt., per capita	TCPCG	5998	6149	6179	6059	6023	5995	6037	6020
Of capital, per capita	TCPCK	64210	52390	40920	31130	64804	64476	65121	64818
In ind., per capita	TCPCI	1689	1738	1751	1726	1639	1683	1643	1640
Unemployed, per capita	TCPCU	423	434	438	434	390	422	390	390
Average per capita	TCPC	1866	1915	1919	1915	1803	1865	1807	1803
Total income (000,000)	TC	30686	31437	31552	31437	30890	30705	30964	30903
Output per capita	RØPC	1019	1185	1210	1021	980	1018	981	981
Total output (000,000)	RØ	16750	16950	16970	16800	16795	16763	16818	16813
GOVERNMENT EXPENDITURES									
Total (000,000)	EG	10433	→	→	→	→	10443	→	→
Ag. inv. (000,000)	EGA	1330	→	→	→	→	→	→	1340
Ind. inv. (000,000)	EGKI	1227	→	→	→	→	→	1237	1227

THE EFFECTS OF INTRODUCING FAMILY PLANNING

The second institutional instrument of government policy included in the model is influence over the population growth rate. Although changing the rate would require expenditures, we have chosen to call this instrument a means of institutional reform, for the expenditures would be relatively small and the changes in attitudes relatively large. That the government should provide its citizens with information and devices to limit the size of their families is neither natural nor customary, and it is neither inevitable nor automatic that the government should shoulder this burden. The difficulty of achievement requires its being placed in the category of institutional change.

In the preceding section we showed the effects of changes in the rate of growth of the population from 2.9 percent to 3 percent and from 3 percent to 3.1 percent per year. These changes were brought about by arbitrarily changing the variable MXRGP, the maximum rate of growth of the population; there was no identification of any mechanism by which the changes could be affected. In Sections III and VII, however, we did formulate such a mechanism -- a government family planning program. Let us now institute that program in the model to determine what might be its effects.

Two equations must be removed from the model whose behavior was simulated in the base and subsequent cases, and eight added. Those removed are Eq. (15), which stated that the rate of growth of the population was a constant, equal to MXRGP, and Eq. (16), which stated that the total population of the Northeast at any instant was equal to its value at the beginning of the simulation plus the amount of growth that had taken place since then.

The second of those two equations is replaced by three others. Instead of a single equation governing throughout the simulation, one operates from 1960 until 1970, when the rate of growth of the population is assumed to have reached its maximum, and another from 1970 till the end of the simulation, when the rate of growth is assumed to be steadily declining from its peak. If LNPT1 and LNPT2 are the expressions

for the (average) rates of growth up to 1970 and beyond 1970 respectively, then the total population, PT, at any instant is determined by Equations (16A), (16B), and (16C):

$$PT1_i = (PTBS)e^{(LNPT1_i)} \tag{16A}$$

where

PT1 = Population, Total, as calculated by the 1st method, number of persons,

PTBS = Population, Total, at the Beginning of the first stage of Simulation (in 1960), a constant, number of persons,

e = natural logarithm, and

LNPT1 = natural logarithm (LN) of the Population, Total, as calculated over the 1st stage, dimensionless,

$$PT2_i = (PTBS2)e^{(LNPT2_i)} \tag{16B}$$

where

PT2 = Population, Total, as calculated by the 2nd method, number of persons,

PTBS2 = Population, Total, at the Beginning of the 2nd stage of the Simulation (in 1970), a constant (depending upon the value of PT reached in that year), number of persons, and

LNPT2 = natural logarithm (LN) of the Population, Total, as calculated over the 2nd stage, dimensionless,

and

If (YEAR) less than or equal to (1970), $PT_i = PT1_i$

If (YEAR) greater than (1970), $PT_i = PT2_i$. (16C)

The first of the equations removed is replaced by five others, two of which describe the initial, gradual rise and subsequent, gradual

fall of the rate of growth of the population. They are

$$LNPT1_i = (RGPDP)(YEAR_i\text{-}1960) + (MXRGP\text{-}RGPDP)(SIRGP)$$

$$\left[-e^{-0.5\left(\frac{SIRGP + 10}{SIRGP}\right)^2} + e^{-0.5\left(\frac{1970\text{-}YEAR_i + SIRGP}{SIRGP}\right)^2}\right] \qquad (15C)$$

where

LNPT1 = natural logarithm (LN) of the Population, Total, as calculated over the 1st stage, dimensionless,

RGPDP = Rate of Growth of the Population in the Distant Past, reciprocal years,

YEAR = the YEAR being simulated,

MXRGP = MaXimum Rate of Growth of the Population, reciprocal years, and

SIRGP = Standard deviation measuring the speed of Increase of the Rate of Growth of the Population, years,

and

$$LNPT2_i = (RGPAF)(YEAR_i\text{-}1970) + (MXRGP\text{-}RGPAF)(SDRGP)$$

$$\left[1-e^{0.5\left\{1-\left(\frac{YEAR_{i\text{-}1970} + SDRGP}{SDRGP}\right)^2\right\}}\right] \qquad (15D)$$

where

LNPT2 = natural logarithm (LN) of the Population, Total, as calculated over the 2nd stage, dimensionless,

MXRGP = MaXimum Rate of Growth of the Population, reciprocal years,

RGPAF = Rate of Growth of the Population Approached in the Future, reciprocal years, and

SDRGP = Standard deviation, measuring the speed of Decline in the Rate of Growth of the Population, years.

The other three equations relate the decline in the growth rate, SDRGP -- the only variable in the set of equations describing the size of the population over which the society has any control -- to the expenditures on family planning, IDRGP. Equations (15A) and (15B) show the reduction in the previous value of SDRGP achieved by the expenditure, by way of an intermediate variable, DSDRG:

$$DSDRG_i = (IDRGC)\ (IDRGP_i) \qquad (15A)$$

$$SDRGP_i = (SDRGP_{i-1})\ (1 - DSRG_i) \qquad (15B)$$

where

DSDRG = intermediate variable, dimensionless

IDRGC = constant relating Investment in family planning to the Decline in the Rate of Growth of the population a Constant, years per baht,

IDRGP = government Investment for the purpose of obtaining a Decline in the Rate of Growth of the Population, baht per year, and

SDRGP = Standard deviation, measuring the quickness of Decline in the Rate of Growth of the Population.

Equation (110) permits the expenditures on family planning to vary with time:

$$IDRGP_i = (IDRPC1)e^{(IDRPC2)(TEBS_i)}. \qquad (110)$$

It will be recalled that we assumed the direct beneficiaries of the expenditure on family planning to be the privately employed persons in the modern sector, their incomes rising by the amount of IDRGP. The other direct beneficiaries are the civil servants, whose numbers and incomes are assumed to rise steadily, although independently of the

volume of expenditures on birth control (implying that resources allocated to this program are taken from other, equally labor-intensive, government programs).

However, family planning may be promoted not because of the direct benefits to family planners but of the indirect benefits to the rest of the population. The reduction in the birth rate permits the total production of the Northeast to be distributed among fewer persons, per capita income and consumption per capita thereby rising. Of interest are by how much, and how the rise is distributed among the different socio-economic groups. To identify the beneficiaries we turn to the results of the simulations.

In all the cases, of which case IGRGP-B in Table 26 is representative, we assumed that expenditures on family planning began in 1960, at the rate of ten million baht per year; in some -- for example, case IGRGP-B -- we assumed that they stayed constant, in others that they rose steadily year by year. The expenditures were not assumed to have any effect upon the rate of growth of the population until 1970, a 10-year lag being common in underdeveloped countries. Thereafter, according to Eq. (15B), the effect of continued expenditures would be to steadily hasten the reduction in the population growth rate.

We assumed that the value of SDRGP, in the absence of an effort to limit births, would be 30 years, this being equivalent to a drop in the instantaneous rate of growth of the population from its peak value of 3.5 percent per year in 1970 to 3.3 percent in 1980, and the average over the decade to 3.4 percent.

With an effort to limit births, SDRGP would fall, to an extent depending upon the magnitude (that is, the initial amount and annual increase in IDRGP) and effectiveness (that is, the value of the parameter IDRGC) of the program. With the relatively modest program of ten million baht per year (one-thirtieth of the total government expenditures in the Northeast in 1970) and a value for IDRGC of 1.0×10^{-9}, SDRGP fell by a little less than 10 percent per year.

The effects of the family planning program on the economy of the Northeast are generally beneficial, both among groups and over time. Total output in agriculture is unaffected by the reduction in the rate of growth of the population, and so the increase in per capita output is directly proportional to the amount expended on birth control. The increase in industrial output is less than proportional to the amount of the expenditures, but the reduction in unemployment is more than proportional: twice as large a family planning program yields more than twice as large a reduction in unemployment.

Although real incomes of all groups rise, as we can see by comparing case IGRGP-B, in which a birth control program is operating, with case IGRGP-A, in which it is not, it is the otherwise unemployed who benefit most. Those who would have already had employment are only marginally better off. The other groups benefit from not having to support the unemployed and from the general rise in per capita output, and from the income generated by the family planning program itself. Given the value we assumed for the constant IDRGC, expenditures on family planning are many, many times as effective in reducing unemployment as investment in agriculture or in industry (compare case IGRGP-B with cases IGRGP-D and -C, respectively). But having no empirical evidence upon which to base the assumption, we must admit that the instrument could be less (or conceivably more) attractive than indicated.*

Economists are accustomed, once they have determined the effects of alternative government policies, to devise a congenial program directed toward achieving the goals of the society. Even if we had sufficient confidence in the accuracy of our analysis, which we do not, we should still be unable to produce any such felicitous combination of policies. Our choice would be rather one among a large number of disagreeable programs, because the chief implication of our analysis

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*The effectiveness of birth control programs in reducing unemployment and raising per capita income will not come as a surprise to anyone following Enke's investigations [508].

is the necessity of a large and sustained transfer of resources to the Northeast to reduce unemployment. Government expenditures, whether they be in engaging civil servants or in carrying out investments, must be massive, far greater than the revenues the government is likely to draw from the region. In prospect, the single largest source of revenue at the present, that derived from the "rice premium," is likely to disappear entirely within the next few years, regardless of what the government does.

Any program we might recommend, therefore, would be at best a choice among harsh alternatives, would involve substantial government expenditures, and then might not eliminate unemployment or substantially raise output per capita. The most effective instrument the government seems to have is its control over the birth rate, for a slight reduction in the rate of growth of the population yields a substantial reduction in unemployment and a general increase in productivity. Were the government willing, this would be the first instrument to apply.

After this major instrument, there are several others that would yield ample returns in terms of reducing unemployment and increasing output. Increasing the size of the civil service by hiring Northeasterners is suitable for the first of these objectives, and increasing investments in agriculture for the first and second. Increasing investments in industry promotes industrialization, and encouraging the creation of a reasonable number of new firms promotes efficiency in the use of resources.

None of this second set of instruments should be used to the exclusion of the others. If investment in industry is carried out without the creation of new firms, each existing firm may accumulate a capital stock greater than that needed for most efficient operation, in the process substituting capital for labor, thereby increasing unemployment. If investment in agriculture precludes investment in industry, or vice versa, the sector not favored fails to advance; only when investment is divided approximately equally between the two sectors does the output of both increase. In our model, unbalanced growth is inferior to balanced growth.

Regardless of what might be the best allocation of a given level of government expenditures, the vital factor seems to be their total amount. In the base case, government expenditures were raised at a rate somewhat over 10 percent per year from 1960, reaching a level of 10 billion baht in the year 1980. The annual rate of increase of over 10 percent produces awesome figures -- at this rate of growth, government expenditures in the Northeast in 1980 are twice total government expenditures in all of Thailand in 1965. Yet these appear to be the minimum magnitudes necessary, in the absence of any substantial decline in the birth rate, to provide nearly full employment for the population of the region.

XII. LIMITATIONS OF THE ANALYSIS AND RECOMMENDATIONS FOR FURTHER STUDY

In Section I we hazarded the guess that the most serious problem confronting the Northeast of Thailand in the next generation is that of providing employment for the population. To estimate the magnitude of the problem and to provide a framework within which it could be visualized we formulated a model of the economic development of the region. Among all the analytic techniques we chose simulation as the most useful; although in Appendix C we also present a simple alternative. Having chosen to apply simulation, we proceeded to formulate the model, which turned out to be complex, requiring approximately one hundred equations. The structure of the model reflected, to the best of our ability and to the extent to which there was information available, the crucial economic relationships. The values for the coefficients in the equations were chosen mainly from Thai statistics, using the 1960 Population Census, 1963 Agricultural Census, and the 1962 Household Budget Studies as the chief sources. Once the model was assembled and the values of parameters and initial conditions estimated, the model was simulated -- first to try to determine its general behavior and second to determine its specific behavior with changes in parameters or in structure. The general pattern of behavior was not surprising: all of the major variables followed plausible growth paths, with the exception of unemployment, which rose very rapidly before finally diminishing. In the base case a peak unemployment of 1,400,000 individuals (workers plus their dependents) was reached.

When the sensitivity of the model was tested in Sections X and XI, the pattern of behavior was unaltered, although the values of the variables took on quite different numbers. The level of unemployment was particularly sensitive to the rate of growth of the population, very small changes in the latter producing very large changes in the former. In efforts to obtain some measure of the magnitude of the task facing the Thai government if it is to promote

full employment in the region and to determine the effectiveness of alternative types of government expenditure, we simulated several cases varying the amount of government activity. The main conclusions were that the volume of government expenditures necessary to eliminate unemployment within a generation is extremely high, rising steadily from current levels at a rate of approximately 20 percent per year; and that government resources will be allocated most effectively when divided in approximately equal proportions between the traditional and modern sectors.

We must resist the temptation to accept uncritically the results of the experiments. There is possibility of error, not only in the magnitudes of the variables but also in the directions of the trends. The possibility of error may be reduced by greater knowledge of the economy of the Northeast and by greater skill in organizing this knowledge, but even analytic perfection cannot eliminate random occurrences. By chance, certain variables may take on quite different values from those predicted, as in the case, for example, of a poor harvest. By chance, the political system may change, invalidating a portion of the model and altering the general pattern of behavior. By chance, new opportunities for employment may arise outside the region, or unexpected assistance be given within.

But there are undoubtedly deficiencies in the analysis that cannot be blamed on chance. We may have focused on the wrong problem or asked the wrong sorts of questions. We may have chosen the wrong approach. Because of its complexity, lack of optimising properties, and unfamiliarity of use with this kind of a problem, simulation may not have been the best technique. We may have formulated the model incorrectly; in one hundred equations there is great room for error. The point in time from which the simulation starts and the values of the coefficients in the equations that determine its future behavior may have been incorrectly estimated; for example, we do not even know with any accuracy the amount of unemployment at the beginning of the experiments. Finally, we may have chosen our experiments unwisely, simulating cases of lesser significance and omitting cases of greater.

It is too late to address ourselves to another issue or to choose another technique; to remedy either of these possible faults would require another study. Yet it is too early to carry out the most significant test of our simulation model -- the comparison of its behavior with experience. To be sure, enough time has passed since 1960 for real and simulated histories to have been unfolded. To be sure, the simulated histories have been recounted in Sections IX through XI and some experience, over the short period from 1960 through 1963, at the beginning of Section X. But the actual development of the economy of the Northeast of Thailand since 1960 is largely unknown. We have a more detailed knowledge of the fiction than of the reality.

Our main recommendations will therefore be directed towards obtaining sufficient data on the current structure and the recent performance of the economy of the Northeast so that the model's ability to accurately reflect reality can be evaluated. But before enumerating the data needed, we wish to mention other reasons why the model might not deserve ready acceptance. One possible deficiency, although one that is not crippling, is that none of the simulations reported in Sections IX through XI is carried out with the best set of inputs. To determine the implications of different initial conditions or of different parameter values, or to simulate different cases is a very simple matter, thanks to the flexibility of the technique and the existence of electronic computers. Anyone who wishes to change the value of any parameter can, by making the appropriate alterations in the program given in Appendix A, carry out the experiment himself.

The remaining qualification, that of possible errors in the formulation of the model, is the one we now address. We shall try to indicate which relationships are most questionable and what would be likely alternatives, for there is not enough information to permit a choice.

Criticism can be levied (except in cases IGRGP, Sect. XI) against assuming a constant population growth rate and an unchanging age structure, but alternative formulations do not yield substantially different behavior. What is important is the numerical rate of population growth. To know this rate accurately is one way to be able to predict the extent

of unemployment. To reduce unemployment will require much effort, of which probably the most efficacious would be directed toward birth control. The evidence is only indicative, for we do not know what expenditures would have to be to produce given reductions in the birth rate nor how long it would be before the reductions appeared. We can only say that if the aim is to reduce unemployment, and if the couples of the Northeast, when provided with the information and devices to limit the size of their families, really wish to do so, then this is probably the best use of government funds.

Moving from the population as a whole to the sub-groups into which we divided it, our analysis may be criticized either for the divisions chosen or for their number. That the traditional sector, which in 1960 employed 93 percent of the population, should have remained undivided, whereas the modern sector, which employed only 7 percent of the population, should have been divided into three groups, may seem disproportionate. Yet if we were to make a further subdivision, our tendency would be to divide the groups in the modern sector still further, for they are more specialized and more heterogeneous than those in the traditional sector. To have considered all those employed by private industry as a single category, rather than to have separated them into skilled and unskilled, or educated and uneducated, may have been to combine different individuals with different motives, different tastes, different incomes, and different opportunities. If the skilled and unskilled respond differently when confronted with changes in income or employment, they should be considered separately; for example, unemployment among the educated may have very different economic and political consequences from unemployment among the uneducated.

The major criticism that can be levied against the portion of the model describing the agricultural sector is probably our choice of a production function that has fixed coefficients. It seemed that this best expressed the way in which Thai farmers act; but our evidence was very scanty, and additional information on rural customs would be welcome. As we discovered when we simulated cases with variable

coefficients in agricultural production and with high mobility of labor between sectors, unemployment would be reduced substantially if the Thais did cultivate the land more intensively. By a change in its formulation the model can accommodate either technique -- the problem is that we do not know for certain which more accurately reflects real behavior.

In the model, increases in outputs were assumed to flow without delay from increases in inputs. The provision of more land by the government, or the tilling of virgin land by the farmers led, within the same year, to a larger harvest. There may well be lags between government investment in agriculture and the increase in output this investment yields, between the extension of cultivation to new land and the harvest of the crop grown upon it. In not allowing for delays, we may have overestimated the returns from production in agriculture, overestimated the income of farmers, and, perhaps, underestimated agricultural employment.

To have assumed that technological progress occurs in agriculture is not to have violated reality, but to have assumed that it occurred independently may have been. In the model, technological progress appeared as a separate term in the production function; each year, automatically and inevitably, the efficiency with which land was cultivated rose at a steady rate. This rate did not vary regardless of the level of government investment: the effect of government investment in agriculture was solely to increase the amount of land that could be cultivated, that is, the quantity of inputs. This formulation can be criticized, for many government activities, such as agricultural extension services and improvement of seeds, do raise productivity. One solution might be to make the rate of improvement endogenous, but then the difficulty would arise that government expenditures in agriculture would have to be divided between those that increase the quantity of inputs and those that increase their quality; and separate relationships would have to be developed for each. We know so little about the effect of government investment in improving agriculture practice that we do not feel capable of making any such formulation.

By assuming that our production function had fixed coefficients and that land was the scarce resource, the problem of bias in technological progress was avoided. Were we to substitute a production function with variable coefficients we should have to decide how the introduction of new techniques would affect the productivity of each of the inputs.

The only link between the inputs of the traditional and the modern sectors is the labor force. Capital was assumed to be immobile, committed irrevocably to one sector or the other. Government investment in agriculture benefited agriculture, and that in industry benefited industry; neither directly promoted an increase in the other sector's output. Most important, the labor force available for work in private industry was calculated only after the population that could be employed in agriculture had been determined. There was no way by which a very high wage in industry could cause farmers with land to abandon its cultivation, nor, at least in the base case, by which a low wage in industry could encourage the more intensive application of labor on farms.

In the original formulation of the supply schedule for industrial labor, the wage in agriculture provided a floor below which the industrial wage would not fall. As the average wage in agriculture rose through time, following increases in productivity, the minimum wage in industry had also to rise, regardless of changes in the average productivity of labor in that sector. It might have been better to have dissolved the link between agricultural and industrial wages, and to have created one between the productivity of labor in agriculture and in industry. In a purely competitive economy with perfect mobility of the factors of production, labor would move from one sector to the other to equate the value of its marginal product. This does not happen in our model; the failure to equate the values of the marginal products might be justified on the grounds that the economy is not purely competitive and that labor is not perfectly mobile. But these are assumptions for which evidence is lacking, and an alternative formulation might be preferable.

In industry itself, the most questionable relationship is probably that between the fraction of the available labor force employed and the wage rate that is paid. Is there a floor to industrial wages? Does the labor supply schedule slope upward? Is there a lag between changes in employment and changes in wages? Can the labor supply schedule be determined solely by reference to the employment rate? A negative answer to any of these questions would require reformulation of the relationship. It might be argued that there is a floor to wages, but that it is set by subsistance rather than by the average wage in the agricultural sector. Or it might be argued that additional workers can be employed, at the same wage rate, up to full employment. It might also be argued that wages respond instantaneously to changes in employment, or perhaps that the lags are different depending upon whether employment rises or falls. Finally, it might be true that institutions, such as labor unions, could raise the wage rate for certain classes of labor above that which would exist if the labor market were competitive, or they might resist a reduction in the wage rate. In each of these situations a different labor supply schedule would hold. In our tests of the sensitivity of the model to changes in its formulation we were able to investigate only two such situations. If other alterations had equal effect upon the behavior of the model, we would be forced to conclude that its behavior is, in general, sensitive to the shape of the supply function and to urge that a search be made into its actual nature.

The decision of private businessmen to employ more or less labor was based upon the assumptions of a homogeneous supply of labor and of the desire of entrepreneurs to maximize their profits. Were either of these assumptions unrealistic, the employment decision would have to be expressed differently. If, for example, businessmen had not only a profit goal but also one of sales or of growth, both employment and output would be higher. Not knowing what the motivations of Thai businessmen are, we have chosen a goal that seems plausible and simplifies our analysis.

Just as labor was assumed to be homogeneous, so was output; and just as labor was assumed to be available when businessmen wished to hire it, so output was assumed to increase when the resources to produce it were available. There were no lags, other than the short solution interval of approximately a month, between soliciting labor and increasing employment, and between increasing employment and raising output.

Our novel production function for private business, which yields first increasing and then diminishing returns to scale, may not reflect the actual conditions of production in the Northeast. Perhaps returns to scale are constant, perhaps steadily increasing, perhaps steadily decreasing, perhaps varying depending upon how the products are being produced and who is producing them; we do not know which of these alternatives is more likely. We chose the production function with variable returns to scale partly for theoretical reasons and partly because we wish to illustrate variations in efficiency with variations in the numbers of new firms. Realizing that the encouragement or discouragement of enterprise is one of the instruments of government, we had to devise a means for evaluating its impact. We do not believe that the choice of production function is crucial within the expected ranges of output, but others may not have gained the same impression.

In the model one of the two prices is fixed and the other is variable, the former reflecting the government's entry into the market for agricultural products and the latter its absence from the market for industrial products. Demands for both goods are variable with changes in their relative prices and in the incomes of consumers. The equations that reflect consumers' demands are typical of those that one finds in economic studies and are therefore unexceptionable. That the values of the elasticities -- with respect to prices and incomes -- should be constant, will also cause little difficulty, for the incomes of the various groups do not change substantially throughout any of the simulations. It is the values of the elasticities themselves that might be questioned, for we have assumed that the figures derived from budget studies, which are on a cross-sectional

basis, are valid over a long interval of time. That consumers should continue to allocate their income in the same proportions as at the present is questionable.

Of perhaps greater consequence is our assumption that only the capitalists save, all other groups consuming their total income. That the other groups do save, at least in small amounts, is more likely. But if their savings take the form of housing or other consumer durables, or in the case of those in the traditional sector of improvement of their farms, this need not concern us. The possibility that they invest in business should, however, but we excluded it to keep our investment function simple. The investment function is already very crude, since it is related only to the income of capitalists and measured as a constant fraction. There may be other variables directly affecting investment -- for example tax rates, government investment and expectations -- but we have neglected these.

Of all of the relationships in the model the most difficult in formulation was that of the response of local entrepreneurs to changes in demand. The Northeast of Thailand is not a closed region: products manufactured elsewhere can be sold there, and manufacturers in the Northeast can sell outside the region. As of 1960, it appeared that about one-third of the manufactured goods consumed there were produced within the region, the remaining two-thirds being imported into it. Even if there were no change in consumption within the region, it would be difficult to estimate what values this fraction might take in the future; with changes in demand, the estimation becomes even more difficult. To assume that the firms in the Northeast can expand, effortlessly, to satisfy a larger and larger fraction of the local demand would be to assume away the problem of unemployment altogether: to assume that they would not expand would be to aggravate it. As we mentioned in Section VI, economic theory is of no assistance in helping us to solve this problem, for under different assumptions it yields contradictory answers. There is also little historical evidence on the shifts in the dependence of poor regions of developing countries upon the outside. Our solution in the base case, which was to assume

that the fraction of total consumption produced locally was constant, was simple and far from ideal. Implicit in this assumption is a form of response on the part of both local and outside manufacturers, namely that collectively each maintains its share of the market. If demand in the region arises by a certain fraction, the sales of local and outside firms will rise by identical fractions. Both groups of producers therefore share equally in the growth of the region.

Alternative assumptions had quite substantial effects upon employment. If the share of the local firms in the region's market rises, employment follows suit and unemployment diminishes: rather small changes in the fraction produced locally yield rather large changes in unemployment. Since the model seems sensitive to changes in the value of the fraction, which itself reflects changes in the response of local and outside firms to changes in demand, it would be wise to obtain a better knowledge of what is actually happening. Is output in the modern sector in the Northeast rising faster than the total demand for its products? At the same rate? Slower? The answer is of considerable importance.

All the variables describing the behavior of the government are wholly exogenous. No attempt was made to relate government expenditures to government revenues, nor to unemployment, income, or any other endogenous variable. This may be unrealistic. One one hand an increase in unemployment might stimulate expenditures designed to overcome it; if this were the response, government deficits in the Northeast could rise to very great amounts. On the other hand, government expenditures might diminish if revenues failed to rise in equal amounts, regardless of the level of unemployment in the region. That both government deficits and unemployment are going to rise we are quite certain, but how the government will act in this situation we do not know.

RECOMMENDATIONS FOR FURTHER STUDY

We have certainly not exhausted the limitations of the model, let alone questioned the choice of problem, technique, and possible solutions. In a technique so new as simulation, and a model so large

as one hundred equations, there are bound to be errors. There may even be some more grievous than those we have identified. But the purposes of this study were not to predict the future of the economy of the Northeast of Thailand nor to construct a development program, but to present a new technique and to provide a guide to empirical research. The hope was modest -- to create some interest in what we believe to be a problem, to attempt to measure its gravity, and to indicate directions in which any interest might be pursued.

In the author's opinion, the next stage in the investigation of the economy of the Northeast of Thailand should be the plentiful gathering and publication of information. Economic theory has led as far as it can: a superior choice among the many alternative formulations of the model awaits a better knowledge of the environment.

There are so little data available relative to the need. The deficiencies are of two sorts: statistical and behavioral. The former deficiencies have been noted again and again throughout the study and will now be apparent to the reader, who will wonder what <u>are</u> the present levels of unemployment, compositions of output and consumption, rates of acculation of capital and clearing of land, and extents of government investment and technological progress?

Some of this information is readily available for Thailand as a whole: for example, National Income Statistics are compiled annually (see [603], [602], and [601]) and surveys of employment and unemployment are conducted periodically (see [612], [613], and [609]). But tabulations by region either appear considerably later than the national data, as in the case of the National Accounts, or do not appear at all, as in the case of the employment surveys. For data on the Northeast alone, some students may be content with the publication, once each decade, of the various Census and Household Budget Studies;* but the

*The presumed dates for the next censuses are 1970 for the Population Census, 1973 for the Agricultural Census, 1976 for the Census of Business [610] and 1973 for the Household Budget Survey. In the Census of Industry conducted in 1964 [611], the results were not broken down by region, but it would be hoped that the 1974 Census would correct this omission.

author finds their appearance too infrequent and would recommend that any data available on a national basis be made available concurrently on a regional basis as well.

Behavioral data are also lacking. Yet without a better understanding of the likely responses -- by those of the inhabitants of the Northeast and by the government officials assigned to their administration -- to different economic and political forces, evaluating the simulation model is hindered and applying any model is hazardous. The sorts of behavioral data needed have been indicated throughout this section. They will be hard to extract and difficult to interpret, but the disturbing prospect of growing unemployment revealed by almost all the alternatives in almost all the simulations does suggest that their discovery would be worthwhile.

Appendix A

DEFINITION OF VARIABLES AND LIST OF EQUATIONS

DEFINITION OF VARIABLES

AFSG	Additional Firms Stimulated directly by the Government, number per year
AFSP	Additional Firms Stimulated by Profits in the industry, number per year
APIKC	Average Propensity to Invest in c(K)apital in industry, a Constant
BØPNE	deficit (-) or surplus (+) in the Balance Øf Payments of the North East, baht per year
CDKI	Cumulative Depreciation of c(K)apital in Industry, baht
CEAAC	Cross-Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant
CEAGC	Cross-Elasticity of demand for Agricultural goods by Government employees, a Constant
CEAIC	Cross-Elasticity of demand for Agricultural goods by Industrial employees, a Constant
CEAKC	Cross-Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant
CEAUC	Cross-Elasticity of demand for Agricultural goods by the Unemployed, a Constant
CEIAC	Cross-Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant
CEIGC	Cross-Elasticity of demand for Industrial goods by Government employees, a Constant
CEIIC	Cross-Elasticity of demand for Industrial goods by Industrial employees, a Constant
CEIKC	Cross-Elasticity of demand for Industrial goods by c(K)apitalists, a Constant
CEIUC	Cross-Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant

CIGA — Cumulative Investment by Government in Agriculture, rai of land

CIGKI — Cumulative Investment of Government in c(K)apital in the Industrial sector, baht

CIKI — Cumulative Investment of private c(K)apital in the Industrial sector, baht

CØAS — Coefficient used in calculating the Øutput of the Agricultural Sector, units per rai per year

CØASC1, 2 — Coefficients used in calculating the Øutput of the Agricultural Sector, Constants

CØIC1-5 — Coefficients used in the calculation of the Øutput of the Industrial sector, Constants, various dimensions

DKI — yearly Depreciation of c(K)apital in Industry, baht per year

DPAØ — Domestic Price of Agricultural Øutput, baht per unit

DPIØ — Domestic Price of the Industrial Øutput, baht per unit

DRKI — Depreciation Rate for c(K)apital in Industry, a fraction

DSDRG — additional Decline in the Standard deviation, measuring the Decline in the Rate of Growth of the population brought about by government expenditures on family planning, dimensionless

DSGA — Deficit or Surplus in Government Accounts for the Northeast, baht per year

DYPEA — Disposable i(Y)ncome of the Population Employed in Agriculture, baht per year

DYPEG — Disposable i(Y)ncome of the Population Employed by Government, baht per year

DYPEI — Disposable i(Y)ncome of the Population Employed in Industry, baht per year

DYPKI — Disposable i(Y)ncome of the Population owning the c(K)apital goods in Industry, baht per year

DYPU — Disposable i(Y)ncome of that portion of the Population Unemployed, baht per year

DYTNE	Disposable i(Y)ncome, Total, of the population in the North East, baht per year
EAØX	Expenditures on Agricultural Øutput eXported from the Northeast, baht per year
EG	Expenditures of the Government in the Northeast, baht per year
EGA	Expenditures by the Government in Agriculture, baht per year
EGAC	annual rate of increase of the capital Expenditures by the Government in Agriculture, dimensionless, a Constant
EGKI	Expenditures by Government increasing the c(K)apital investment of Industry, baht per year
EGKIC	yearly rate of increase in the Expenditures by the Government increasing the c(K)apital investment of Industry, dimensionless, a Constant
EIØK	Expenditures in Industrial Øutput by the owners of the c(K)apital invested in industry, baht per year
EXNE	payments for EXports from the North East, baht per year
FAEI	the Fraction of those Available for Employment in Industry actually employed, dimensionless
FAID	Foreign AID received by the Thai government for expenditure in the Northeast, baht per year
FIØN	Fraction of Industrial Øutput consumed that is produced in the Northeast, dimensionless
FIØNC1, 2	coefficients used in determining that Fraction of the Industrial Øutput consumed that is produced in the Northeast, Constants, dimensionless
FPAØ	Foreign Price of the Agricultural Øutput, baht per unit
IDRGC	constant relating Investment in family planning to the Decline in the Rate of Growth of the population, a Constant
IDRGP	Government Investment designed to produce a Decline in the Rate of Growth of the Population, baht per year

IGAC	coefficient used in determining the productivity of the Investment by the Government in increasing the stock of land in Agriculture, a Constant
IGKI	Investment by Government in the c(K)apital of Industry, baht per year
IGLA	Investment by the Government augmenting the stock of Land in Agriculture, rai per year
IKI	Investment by private entrepreneurs in the c(K)apital in Industry, baht per year
IMNE	payments for IMports into the North East, baht per year
IWEGC	Increase in the Wage paid to those Employed by Government, dimensionless, a Constant
KI	total stock of c(K)apital in Industry, baht
KIEB	stock of c(K)apital in Industry Existing in the Base year, baht
KLB	c(K)apital available for use in agriculture, represented by the total stock of arable Land in the Base year, rai of land
KUA	c(K)apital Utilized in Agricultural production, rai
KUAC1, 2	coefficients used in estimating the increase through time of the portion of the c(K)apital invested in land that is actually Utilized in Agricultural production, a Constant
LLRA	Labor/Land Ratio in Agriculture, individuals per rai
LNPT	Logarithm (Natural) of the Population, Total
MPPL	Marginal Physical Product of Labor, units of product per man-year
MRIØ	Marginal Revenue of Industrial Øutput, baht per unit
MXRGP	MaXimum Rate of Growth of the Population, fraction per year
NFEGC	Number of new Firms Established by the Government, relative to the number already in existence, a Constant
NFEKC	Number of Firms Established as a consequence of the profitability of c(K)apital in industry, a Constant, number per baht per person

NFI	Number of Firms in Industry
ØAS	Øutput of the Agricultural Sector, units per year
ØFI	Øutput Function for the private Industry, dimensionless
ØIS	Øutput of the Industrial Sector, units per year
PAEI	Population Available for Employment in private Industry and services, numbers of individuals (plus families)
PCAA	Per capita Consumption of Agricultural goods by the population employed in Agriculture, units per individual per year
PCAAC	coefficient used in calculation of PCAA, a Constant
PCAG	Per capita Consumption of Agricultural goods by Government employees, units per individual per year
PCAGC	coefficient used in calculation of PCAG, a Constant
PCAI	Per capita Consumption of Agricultural goods by Industrial employees, units per individual per year
PCAIC	coefficient used in calculation of PCAI, a Constant
PCAK	Per capita Consumption of Agricultural goods by c(K)apitalists, units per individual per year
PCAKC	coefficient used in calculation of PCAK, a Constant
PCAU	Per capita Consumption of Agricultural goods by the Unemployed, units per year
PCAUC	coefficient used in calculating PCAU, a Constant
PCIA	Per capita Consumption of Industrial goods by the population employed in Agriculture, units per individual per year
PCIAC	coefficient used in calculation of PCIA, a Constant
PCIG	Per capita Consumption of Industrial goods by Government employees, units per individual per year
PCIGC	coefficient used in calculation of PCIG, a Constant
PCII	Per capita Consumption of Industrial goods by Industrial employees, units per individual per year

PCIIC coefficient used in calculation of PCII, a Constant

PCIK Per capita Consumption of Industrial goods by c(K)apitalists, units per individual per year

PCIKC coefficient used in calculation of PCIK, a Constant

PCIU Per capita Consumption of Industrial goods by the Unemployed, units per year

PCIUC coefficient used in determining PCIU, a Constant

PCPEA Per capita Consumption of the Population Employed in Agriculture, baht per individual per year

PCPEG Per capita Consumption of the Population Employed by Government, baht per individual per year

PCPEI Per capita Consumption of the Population Employed in Industry, baht per individual per year

PCPKI Per capita Consumption of the Population owning the c(K)apital goods employed in Industry, baht per person per year

PCPU Per Capita of those individuals in the Population who are Unemployed, baht per year

PEA Population Employed in the Agricultural (traditional) sector, number of individuals

PEAAC Price Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant

PEAGC Price Elasticity of demand for Agricultural goods by Government employees, a Constant

PEAIC Price Elasticity of demand for Agricultural goods by Industrial employees, a Constant

PEAKC Price Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant

PEAUC Price Elasticity of demand for Agricultural goods by the Unemployed, a Constant

PEG Population Employed by Government, number of individuals

PEI Population Employed in private Industry, number of individuals

PEIAC — Price Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant

PEIGC — Price Elasticity of demand for Industrial goods by Government employees, a Constant

PEIIC — Price Elasticity of demand for Industrial goods by Industrial employees, a Constant

PEIKC — Price Elasticity of demand for Industrial goods by c(K)apitalists, a Constant

PEIUC — Price Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant

PØKI — Population Øwning the c(K)apital invested in Industry, number of individuals

PT — Population, Total number of individuals

PTBS — the total PopulaTion, at the Beginning of the Simulation, number of individuals

PU — Population Unemployed, number of individuals

RG — total Revenues of the Government derived from the Northeast, baht per year

RGPAF — Rate of Growth of the Population Approached in the Future, fraction per year

RGPDP — Rate of Growth of the Population Departed from in the Past, fraction per year

RICEP — RICE Premium, baht per unit of agricultural output

RICEX — RICE eXports in the base year, tons per year, a constant

SDRGP — Standard deviation, measuring the quickness of Decline in the Rate of Growth of the Population, years

TCAA — Total Consumption of Agricultural goods by the population employed in Agriculture, units per year

TCAG — Total Consumption of Agricultural products by Government employees, units per year

TCAK — Total Consumption of Agricultural products by owners of c(K)apital goods in industry, units per year

TCAI	Total Consumption of Agricultural products by population employed in Industry, units per year
TCAØ	Total Consumption of Agricultural Øutput in the Northeast, units per year
TCAU	Total Consumption of Agricultural products by the Unemployed, units per year
TCIA	Total Consumption of Industrial goods by the population employed in Agriculture, units per year
TCIAV	Total Consumption of Industrial goods in the Northeast AVeraged, units per year
TCIC1, 2	coefficients used in averaging the Total Consumption of Industrial goods in the Northeast, dimensionless, Constants
TCIG	Total Consumption of Industrial goods by Government employees, units per year
TCIK	Total Consumption of Industrial goods by the owners of c(K)apital equipment in industry, units per year
TCII	Total Consumption of Industrial goods by the population employed in Industry, units per year
TCIØ	Total Consumption of Industrial Øutput, units per year
TCIU	Total Consumption of Industrial goods by the Unemployed, units per year
TEBS	Time Elapsed since the Beginning of the Simulation, years
TPAU	Transfer Payments from those employed in Agriculture to those Unemployed, baht per year
TPAUC	maximum Transfer Payments from those employed in Agriculture to the Unemployed, as a fraction of the donors' income, a Constant
TPEM	Transfer Payments from EMigreés to the population employed in agriculture, baht per year
TPGA	Transfer Payments from the population employed by Government to that employed in Agriculture, baht per year

TPGAC	maximum Transfer Payments from Government employees to those employed in Agriculture, as a fraction of the donors' income, a Constant
TPGU	Transfer Payments from Government employees to the Unemployed, baht per year
TPGUC	maximum Transfer Payments from Government employees to the Unemployed, as a fraction of the donors' income, a Constant
TPIA	Transfer Payments from the population employed in Industry to that employed in Agriculture, baht per year
TPIAC	maximum Transfer Payments from the population employed in Industry to the population employed in Agriculture, as a fraction of the donors' incomes, a Constant
TPIU	Transfer Payments from the population employed in Industry to the Unemployed, baht per year
TPIUC	maximum Transfer Payments from the population employed in Industry to the Unemployed, as a fraction of the donors' income, a Constant
TXAX	TaXes collected in Agricultural eXports from the North-east, baht per year
TXPAC	TaX rate on the Population employed in Agriculture, baht per person, a Constant
TXPEA	TaXes collected directly from the Population Employed in Agriculture, baht per year
TXPEG	TaXes levied on the Population Employed by Government, baht per year
TXPEI	TaXes levied on the Population Employed by Industry, baht per year
TXPGC	TaX rate on the Population employed by Government, baht per person, a Constant
TXPIC	TaX rate on the Population employed in private Industry, baht per person per year, a Constant
TXPKC	TaX rate on the income of the Population owning c(K)apital goods, dimensionless, a Constant
TXPKI	TaXes on the Population owning the c(K)apital in Industry, baht per year

VAØ	Value of Agricultural Øutput, baht per year
VIMI	Value of the IMports of Industrial goods into the Northeast, baht per year
VIØ	Value of the Industrial Øutput, baht per year
WDFC	Wage DiFferential between wages in industry and in agriculture necessary to mobilize the unemployed, dimensionless, a Constant
WEA	annual Wage of those Employed in Agriculture, baht per person per year
WEG	average Wage paid to each individual in the Employ of the Government, baht per year
WEGB	Wage of those Employed by Government at the Beginning of the simulation, baht per individual per year
WEI	annual Wage of those Employed in Industry, baht per person per year
WEIAV	annual Wage of those Employed in private Industry, AVeraged, baht per person per year
WEIC1, 2	coefficients used in determining the average annual Wage of those Employed in private Industry, Constants, dimensionless
YEAAC	i(Y)ncome Elasticity of demand for Agricultural goods by the population employed in Agriculture, a Constant
YEAGC	i(Y)ncome Elasticity of demand for Agricultural goods by Government employees, a Constant
YEAKC	i(Y)ncome Elasticity of demand for Agricultural goods by c(K)apitalists, a Constant
YEAIC	i(Y)ncome Elasticity of demand for Agricultural goods by Industrial employees, a Constant
YEAUC	i(Y)ncome Elasticity of demand for Agricultural goods by the Unemployed, a Constant
YEIAC	i(Y)ncome Elasticity of demand for Industrial goods by the population employed in Agriculture, a Constant
YEIGC	i(Y)ncome Elasticity of demand for Industrial goods by Government employees, a Constant

YEIIC	i(Y)ncome Elasticity of demand for Industrial goods by Industrial employers, a Constant
YEIKC	i(Y)ncome Elasticity of demand for Industrial goods by c(K)apitalists, a Constant
YEIUC	i(Y)ncome Elasticity of demand for Industrial goods on the part of the Unemployed, a Constant
YKI	i(Y)ncome of those owning the c(K)apital in Industry, baht per year
YPCNE	i(Y)ncome Per Capita in the North East, baht per person per year
YPEA	annual earned i(Y)ncome of the Population Employed in Agriculture, baht per year
YPEG	earned i(Y)ncome of the Population Employed by Government, baht per year
YPEI	annual earned i(Y)ncome of the Population Employed in Industry, baht per year
YTNE	i(Y)ncome, Total, for the North East, baht per year

LISTING OF PROGRAM RUNNING DECK

```
$JOB          4008,ENDS,T6150,05M,OCD,200P,P          PAL 109
$IBJOB
$IBFTC SPENT                                           * * *   1 * * *SPENT
C                                                                      SPENT   1
C         SIMULATION PROGRAM OF THE ECONOMY OF NORTHEAST THAILAND.     SPENT   2
C         READS AND PRINTS INPUTS AND CONTROLS SIMULATION.             SPENT   3
C         USES ROUTINES CYCLE, POUT, HEAD.                             SPENT   4
C         USES SYSTEM ROUTINES ATHRUZ, AND BCDCON.                     SPENT   5
C                                                                      SPENT   6
C                                                                      SPENT  10
C     NAME   - LIST OF VARIABLE NAMES USED IN CALC                     SPENT  15
C     V      - LIST OF CURRENT VALUES OF VARIABLES                     SPENT  20
C     A      - OUTPUT ARRAY - ALL VARIABLES, ALL YEARS                 SPENT  25
C     PNAM   - LIST OF VARIABLE NAMES TO BE OUTPUT IN ORDER OF OUTPUTINGSPENT  30
C     NVO - NUMBER OF OUTPUT VARIABLES                                 SPENT  35
C     NY  - INDEX TO OUTPUT MATRIX OF LAST YEAR STORED                 SPENT  40
C     NYT - NUMBER OF COLUMNS OF OUTPUT PRINT   PER PAGE               SPENT  45
C     NV  - TOTAL NUMBER OF VARIABLES                                  SPENT  50
C     NOF    - FLAG - IF=1, CONTINUE READING OUTPUT VAR NAMES          SPENT  55
C     VAR    - INPUT MNUMONIC VARIABLE NAME                            SPENT  60
C     VALUE - INPUT VARIABLE VALUE                                     SPENT  65
C     COMMET - INPUT COMMENT                                           SPENT  70
C                                                                      SPENT  75
      COMMON /VC/  V(250)                                              SPENT  80
      COMMON/AC/ A(20,250), NAME(250),PNAM(250),COMMET(20)             SPENT  85
      COMMON/AC/  NVO,NY,NYT,NV,VAR,VALUE,NOF, NCOLP,NCYP,ICYP,ICOLP   SPENT  90
      COMMON /HC/ NCASE, LINE                                          SPENT  95
      REAL   NAME                                                      SPENT100
C                                                                      SPENT105
      EQUIVALENCE  (YEAR,V(3)), (EYEAR,V(154))                         SPENT110
      EQUIVALENCE  (COLP,V(155)), (CYP,V(156)), (CYOP,V(157))          SPENT115
      EQUIVALENCE (CNYT,V(159)), (ERROR,V(195))                        SPENT120
      DIMENSION VA(2),FMT(5)                                           SPENT125
C                                                                      SPENT130
      NCOUNT = 0                                                       SPENT135
      NCASE = 0                                                        SPENT140
      CALL ATHRUZ(OUT,3HOUT)                                           SPENT145
      CALL ATHRUZ(END,3HEND)                                           SPENT150
      CALL ATHRUZ(BK,1H )                                              SPENT155
      CALL BCDCON(VA(1))                                               SPENT160
      CALL ATHRUZ(FNORM,6HF12.0 )                                      SPENT165
      CALL ATHRUZ(FMT(1),6H(     )                                     SPENT170
      CALL ATHRUZ(FMT(5),6H     ))                                     SPENT175
      NV = 250                                                         SPENT180
C                                                                      SPENT185
C          EXECUTE ONE CASE                                            SPENT190
    5 NY = 1                                                           SPENT195
      NCASE = NCASE + 1                                                SPENT200
      NFO = 0                                                          SPENT205
      NCOLP = 1                                                        SPENT210
      NCYP = 0                                                         SPENT215
      CYOP = 0.                                                        SPENT220
      ERROR = 0.                                                       SPENT225
      CALL HEAD                                                        SPENT230
C                                                                      SPENT235
C          LOOP THRU INPUT CARDS FOR ONE CASE                          SPENT240
   10 READ(5,11) B,VAR,VA,    (COMMET(J),J=1,16)                       SPENT245
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   11 FORMAT(A3,1X,A6,2A6,  8(A6,A1))                              SPENT250
      IF(LINE.GT.54) CALL HEAD                                     SPENT255
      WRITE(6,12) B,VAR,VA,   (COMMET(J),J=1,16)                   SPENT260
   12 FORMAT(1X,A3,1X,A6,2A6,   8(A6,A1))                          SPENT265
      LINE = LINE + 1                                              SPENT270
      IF(B.EQ.OUT) GO TO 20                                        SPENT275
      IF(B.EQ.END) GO TO 30                                        SPENT280
      DO 14 I = 1,250                                              SPENT285
   14 IF(VAR.EQ.NAME(I)) GO TO 16                                  SPENT290
      WRITE(6,15)  VAR                                             SPENT295
   15 FORMAT(1X,A6,21H CHECK VARIABLE NAME.)                       SPENT300
      GO TO 10                                                     SPENT305
C                                                                  SPENT310
C             SET INPUT VALUES AND VARIABLE NAMES                  SPENT315
   16 IF(COMMET(1).EQ.BK) GO TO 18                                 SPENT320
      FMT(2) = COMMET(1)                                           SPENT325
      FMT(3) = COMMET(2)                                           SPENT330
      FMT(4) = COMMET(3)                                           SPENT335
      GO TO 19                                                     SPENT340
   18 FMT(2) = FNORM                                               SPENT345
      FMT(3) = BK                                                  SPENT350
      FMT(4) = BK                                                  SPENT355
   19 READ(99,FMT) V(I)                                            SPENT360
      GO TO 10                                                     SPENT365
C                                                                  SPENT370
C             CONSTRUCT LIST OF VARIABLE NAMES TO BE OUTPUT        SPENT375
   20 IF(NOF.EQ.1) GO TO 25                                        SPENT380
      NVO = 0                                                      SPENT385
      NOF = 1                                                      SPENT390
   25 DO 28 I = 1,15,2                                             SPENT395
      IF(COMMET(I).EQ.BK) GO TO 28                                 SPENT400
      NVO = NVO + 1                                                SPENT405
      PNAM(NVO) = COMMET(I)                                        SPENT410
   28 CONTINUE                                                     SPENT415
      GO TO 10                                                     SPENT420
C                                                                  SPENT425
C             ALL INPUTS READ FOR THIS CASE                        SPENT430
C             SAVE INPUTS FOR FUTURE CASES                         SPENT435
   30 ICYP = CYP                                                   SPENT440
      ICOLP = COLP                                                 SPENT445
      NYT = CNYT                                                   SPENT450
      DO 35 I = 1,250                                              SPENT455
   35 A(1,I) = V(I)                                                SPENT460
      NOF = 0                                                      SPENT465
C                                                                  SPENT470
C                                                                  SPENT475
   40 CALL CYCLE                                                   SPENT480
C             IF ERROR SKIP TO NEXT CASE                           SPENT485
      IF(ERROR.NE.0.) CALL POUT                                    SPENT490
      IF(ERROR.NE.0.) GO TO 49                                     SPENT495
      NCOUNT = NCOUNT + 1                                          SPENT500
C                                                                  SPENT505
C             TEST IF THIS CYCLE TO BE OUTPUT                      SPENT510
      NCYP = NCYP + 1                                              SPENT515
      IF(NCYP.NE.ICYP) GO TO 40                                    SPENT520
      NCYP = 0                                                     SPENT525
C                                                                  SPENT530
C             YES - STORE RESULTS FOR LATER PRINTING               SPENT535
      NCOLP = NCOLP + 1                                            SPENT540
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      NY = NY + 1                                                       SPENT545
      DO 45 I = 1,250                                                   SPENT550
   45 A(NY,I) = V(I)                                                    SPENT555
C                                                                       SPENT560
C            TEST FOR PRINTING                                          SPENT565
      IF(NY.NE.NYT.AND.NCOLP.LE.ICOLP) GO TO 40                         SPENT570
      CALL POUT                                                         SPENT575
      DO 48 I = 1,250                                                   SPENT580
      DO 48 J = 2,20                                                    SPENT585
   48 A(J,I) = 0.                                                       SPENT590
      NY = 1                                                            SPENT595
      IF(NCOLP.LE.ICOLP) GO TO 40                                       SPENT600
C                                                                       SPENT605
C            END OF CASE - RESTORE INPUTS FOR NEXT CASE                 SPENT610
   49 DO 50 I = 1,250                                                   SPENT615
   50 V(I) = A(1,I)                                                     SPENT620
      GO TO 5                                                           SPENT625
      END                                                               SPENT630
$IBFTC CYCLE
      SUBROUTINE CYCLE                                                  CYCLE  0
C                                                                       CYCLE  1
C          SIMULATES ONE TIME INCREMENT.  CALLED BY MAIN ROUTINE SPENT. CYCLE  2
C                                                                       CYCLE  3
C          USES NO SUBROUTINES.                                         CYCLE  4
C                                                                       CYCLE 10
      COMMON/VC/ DT,     TEBS,   YEAR,   PEG,    INPEG,  COASC1,COASC2,IGAC, CYCLE 15
     1           EGA,    CIGA,   KUAC1,  KUAC2,  KLB,    LLRA,   NFI,    NFEKC,CYCLE 20
     2           NFEGC,  MXRGP,  PTBS,   EGKI,   CIGKI,  APIKC,  EIOK,   CIKI, CYCLE 25
     3           KI,     DRKI,   KIEB,   FPAU,   RICEP,  TCIO,   FIONC1,FIONC2,CYCLE 30
     4           COIC1,  COIC2,  COIC3,  COIC4,  COIC5,  OFIC3,  OFIC1,  OFIC2,CYCLE 35
     5           WDFC,   WEGB,   IWEGC,  TPGAC,  TPGUC,  TXPGC,  TPIAC,  TPIUC,CYCLE 40
     6           TXPIC,  TXPKC,  TPAUC,  TXPAC,  TPEM,   PEAAC,  CEAAC,  YEAAC,CYCLE 45
     7           PCAAC,  CEIAC,  PEIAC,  YEIAC,  PCIAC,  PEAGC,  CEAGC,  YEAGC,CYCLE 50
     8           PCAGC,  CEIGC,  PEIGC,  YEIGC,  PCIGC,  PEAKC,  CEAKC,  YEAKC,CYCLE 55
     9           PCAKC,  CEIKC,  PEIKC,  YEIKC,  PCIKC,  PEAIC,  CEAIC,  YEAIC CYCLE 60
      COMMON/VC/ PCAIC,  CEIIC,  PEIIC,  YEIIC,  PCIIC,  PEAUC,  CEAUC,  YEAUC,CYCLE 65
     1           PCAUC,  CEIUC,  PEIUC,  YEIUC,  PCIUC,  RICEX,  FAID,   PT,   CYCLE 70
     2           PEA,    PEI,    PDKI,   PU,     WEA,    WEI,    WEG,    DPIO, CYCLE 75
     3           KUA,    OAS,    AFSP,   AFSG,   CDKI,   OFI,    OIS,    MPPL, CYCLE 80
     4           TPGA,   TPGU,   YPEA,   YPEG,   YKI,    PCPEA,  PCPEG,  PCPKI,CYCLE 85
     5           PCPEI,  PCPU,   TCAU,   EAUX,   TXAX,   VIMI,   RG,     EG,   CYCLE 90
     6           DSGA,   YTNE,   EXNE,   IMNE,   BOPNE,  ETNE,   DYTNE,  YPCNE,CYCLE 95
     7           COAS,   IGLA,   LIPBS,  PAEI,   IGKI,   IKI,    OKI,    DPAO, CYCLE100
     8           VAO,    FION,   FAEI,   MRIO,   DPZZ,   VIO,    TXPEG,  DYPEG,CYCLE105
     9           YPEI,   EYEAR,  COLP,   CYP,    CYOP,   DTT,    CNYT          CYCLE110
      COMMON/VC/ TCAG,   TCAI,   TCIK,   PEAU,   PCAK,   TXPEA,  TCAK,   TCAO, CYCLE115
     1           TPGZZ,  PCIU,   IZZZ,   DYPEA,  TCIU,   PCAU,   TXPKI,  PEGB, CYCLE120
     2           TPIU,   PCIA,   DYPEI,  TCIA,   PCIG,   TPAU,   PCAA,   PCII, CYCLE125
     3           TPIA,   TCIG,   TCAA,   PCAG,   DYPU,   DYPKI,  TCII,   TXPEI,CYCLE130
     4           PCIK,   PCAI,   CHECK,  ERROR,  TCIC1,  TCIC2,  TCIAV,  EGAC, CYCLE135
     5           EGKIC,  EGKIC1,EGAC1,   WEIAV,  WEIC1,  WEIC2,  KIF           CYCLE140
      REAL       INPEG,  IGAC,   KUAC1,  KUAC2,  KLB,    LLRA,   NFI,    NFEKC CYCLE145
      REAL       NFEGC,  MXRGP,  KI,     KIEB,   IWEGC,  KUA,    MPPL,   IMNE  CYCLE150
      REAL       IGLA,   LIPBS,  IGKI,   IKI,    MRIO,   IMNE,   KIF           CYCLE155
C                                                                       CYCLE160
      DIMENSION V(250)                                                  CYCLE165
      EQUIVALENCE (DT,V(1))                                             CYCLE170
      COMMON/AC/ A(20,250), NAME(250),PNAM(250),COMMET(20)              CYCLE175
      COMMON/AC/  NVO,NY,NYT,NV,VAR,VALUE,NOF, NCOLP,NCYP,ICYP,ICOLP    CYCLE180
      REAL    NAME                                                      CYCLE185
```

```
      DATA NAME1/    300HDT     TEBS  YEAR  PEG   INPEG COASC1COASC2IGAC
     1EGA   CIGA  KUAC1 KUAC2 KLB   LLRA  NFI   NFEKC NFEGC MXRGP PTBS
     2EGKI  CIGKI APIKC EIOK  CIKI  KI    DRKI  KIEB  FPAO  RICEP TCIO
     3FIONC1FIONC2COIC1 COIC2 COIC3 COIC4 COIC5 OFIC3 OFIC1 OFIC2 WDFC
     4WEGB  IWEGC TPGAC TPGUC TXPGC TPIAC TPIUC TXPIC TXPKC /
      DATA NAME2/    300HTPAUC TXPAC TPEM  PEAAC CEAAC YEAAC PCAAC CEIAC
     1PEIAC YEIAC PCIAC PEAGC CEAGC YEAGC PCAGC CEIGC PEIGC YEIGC PCIGC
     2PEAKC CEAKC YEAKC PCAKC CEIKC PEIKC YEIKC PCIKC PEAIC CEAIC YEAIC
     3PCAIC CEIIC PEIIC YEIIC PCIIC PEAUC CEAUC YEAUC PCAUC CEIUC PEIUC
     4YEIUC PCIUC RICEX FAID  PT    PEA   PEI   POKI  PU    /
      DATA NAME3/    300HWEA   WEI   WEG   DPIO  KUA   OAS   AFSP  AFSG
     1COKI  OFI   OIS   MPPL  TPGA  TPGU  YPEA  YPEG  YKI   PCPEA PCPEG
     2PCPKI PCPEI PCPU  TCAU  EAOX  TXAX  VIMI  RG    EG    DSGA  YTNE
     3EXNE  IMNE  BOPNE ETNE  DYTNE YPCNE COAS  IGLA  LIPBS PAEI  IGKI
     4IKI   DKI   DPAO  VAO   FION  FAEI  MRIO  DPZZ  VIO   /
      DATA NAME4/    300HTXPEG DYPEG YPEI  EYEAR COLP  CYP   CYOP  DTT
     1CNYT  TCAG  TCAI  TCIK  PEAU  PCAK  TXPEA TCAK  TCAO  TPGZZ PCIU
     2IZZZ  DYPEA TCIU  PCAU  TXPKI PEGB  TPIU  PCIA  DYPEI TCIA  PCIG
     3TPAU  PCAA  PCII  TPIA  TCIG  TCAA  PCAG  DYPU  DYPKI TCII  TXPEI
     4PCIK  PCAI  CHECK ERROR TCIC1 TCIC2 TCIAV EGAC  EGKIC /
      DATA NAME5/    300HEGKIC1EGAC1 WEIAV WEIC1 WEIC2 KIF
     1
     2
     3
     4                                                      /
C                ADD NEW VARIABLE NAMES TO COMMON BLOCK /VC/ AND DATA
C                NAME LIST. NAMES MUST BE IN SAME ORDER ON BOTH LISTS.
      DIMENSION NAME1(50),NAME2(50),NAME3(50),NAME4(50),NAME5(50)
      EQUIVALENCE (NAME(1),NAME1(1)),(NAME(51),NAME2(1))
      EQUIVALENCE (NAME(101),NAME3(1)),(NAME(151),NAME4(1))
      EQUIVALENCE (NAME(201),NAME5(1))
C
      CYOP = CYOP + 1.
C1
      DTT = DTT + DT
C2
      TEBS = DTT/100.
C3
      YEAR = YEAR + DT /100.
C4
      PEG = PEGB*EXP(INPEG*TEBS)
C5
      COAS = COASC1*EXP(COASC2*TEBS)
C5A
      EGA = EGAC1*EXP(EGAC*TEBS)
C6
      IGLA = IGAC*EGA
C7
      CIGA = CIGA + IGLA
C8
      KUA = (KLB + CIGA)/(1.+KUAC1*EXP(-KUAC2*TEBS))
C9
      OAS = COAS*KUA
C10
      PEA = LLRA*KUA
C11
      AFSP = NFEKC*NFI PCPKI
C12
      AFSG = NFEGC*NFI
```

```
C13
      NFI = NFI + AFSP + AFSG
C14
      POKI = NFI
C15
      LIPBS = MXRGP*TEBS
C16
      PT = PTBS*EXP(LIPBS)
C17
      PAEI = PT - PEA - POKI - PEG
C17A
      EGKI = EGKIC1*EXP(EGKIC*TEBS)
C18
      IGKI = EGKI / 10.
C19
      CIGKI = CIGKI + IGKI
C20
      IKI = (APIKC)*(EIOK)
C21
      CIKI = CIKI + IKI
C22
      DKI = (DRKI)*(KI)
C23
      CDKI = CDKI + DKI
C24
      KI = KIEB + CIGKI + CIKI - CDKI
C25
      DPAO = FPAO - RICEP
C26
      VAO = (OAS)*(DPAO)
C27
      YPEA = VAO
C28
      WEA = YPEA / PEA
C29
      FION = (FIONC1)*(     EXP(FIONC2 * TEBS))
C29A
      TCIAV = TCIAV*TCIC1 + TCIO*TCIC2
C30
      OIS = FION *TCIAV
C31
      OFI =(COIC4 + COIC5*(TEBS))/(-ALOG(OIS) + ALOG(NFI) + ALOG(COIC1)+
     1COIC2 + COIC3*(TEBS))
C32
      CHECK = OFIC3*OFI/(KI/NFI)**OFIC1
      IF(CHECK.LT.0.) GO TO 101
      PEI = NFI*CHECK**(1./OFIC2)
C33
      FAEI = PEI / PAEI
C34
      WEI = WEA*(1.+ (WDFC/(1.-FAEI)))
C34A
      WEIAV = (WEIAV)*(WEIC1) + (WEI)*(WEIC2)
C35
      MPPL = (OIS/PEI)*(OFIC2)*(COIC4 + COIC5*(TEBS) / OFI)
C36
      MRIO = WEIAV/MPPL
C37
      DPIO = MRIO
C38
```

```
      VIO = (DIS)*(DPIO)
C39
      WEG = (WEGB)*EXP(IWEGC * TEBS)
C40
      YPEG = (PEG)*(WEG)
C41
      PU = PAEI - PEI
C42
      TPGA = (PEA / (PEA + PEG))*(YPEG)*(TPGAC)
C43
      TPGU = (PU / (PU + PEG))*(YPEG)*(TPGUC)
C44
      TXPEG = (PEG)*(TXPGC)
C45
      DYPEG = YPEG - TPGA - TPGU - TXPEG
C46
      YPEI = (PEI)*(WEIAV)
C47
      TPIA = (PEA / (PEA + PEI))*(YPEI)*(TPIAC)
C48
      TPIU = (PU / (PU + PEI))*(YPEI)*(TPIUC)
C49
      TXPEI = (PEI)*(TXPIC)
C50
      DYPEI = YPEI - TPIA - TPIU - TXPEI
C51
      YKI = VIO - YPEI
C52
      TXPKI = (YKI)*(TXPKC)
C53
      DYPKI = YKI - TXPKI
C54
      TPAU = (PU / (PU + PEA))*(YPEA)*(TPAUC)
C55
      TXPEA = (PEA)*(TXPAC)
C56
      DYPEA = YPEA - TPAU - TXPEA + TPGA + TPIA + TPEM
C57
      DYPU = TPGU + TPIU + TPAU
C58
      PCPEA = DYPEA / PEA
C59
      IF(DPAO .LT.0.) GO TO 102
      IF(DPIO .LT.0.) GO TO 103
      IF(PCPEA.LT.0.) GO TO 104
      PCAA = (DPAO)**PEAAC*(DPIO)**CEAAC*(PCPEA)**YEAAC*(PCAAC)
C60
      PCIA = (DPAO)**CEIAC*(DPIO)**PEIAC*(PCPEA)**YEIAC*(PCIAC)
C61
      PCPEG = DYPEG / PEG
C62
      IF(PCPEG.LT.0.) GO TO 105
      PCAG = (DPAO)**PEAGC*(DPIO)**CEAGC*(PCPEG)**YEAGC*(PCAGC)
C63
      PCIG = (DPAO)**CEIGC*(DPIO)**PEIGC*(PCPEG)**YEIGC*(PCIGC)
C64
      PCPKI = DYPKI / POKI
C65
      IF(PCPKI.LT.0.) GO TO 106
```

```
      PCAK = (DPAO)**PEAKC*(DPIO)**CEAKC*(PCPKI)**YEAKC*(PCAKC)          CYCLE 95
C66                                                                       CYCLE 95
      PCIK = (DPAO)**CEIKC*(DPIO)**PEIKC*(PCPKI)**YEIKC*(PCIKC)          CYCLE 95
C67                                                                       CYCLE 95
      PCPEI = DYPEI / PEI                                                 CYCLE 95
C68                                                                       CYCLE 95
      IF(PCPEI.LT.0.) GO TO 107                                           CYCLE/
      PCAI = (DPAO)**PEAIC*(DPIO)**CEAIC*(PCPEI)**YEAIC*(PCAIC)          CYCLE/ 5
C69                                                                       CYCLE/10
      PCII = (DPAO)**CEIIC*(DPIO)**PEIIC*(PCPEI)**YEIIC*(PCIIC)          CYCLE/15
C70                                                                       CYCLE/20
      PCPU = DYPU / PU                                                    CYCLE/25
C71                                                                       CYCLE/30
      IF(PCPU .LT.0.) GO TO 108                                           CYCLE/35
      PCAU = (DPAO)**PEAUC*(DPIO)**CEAUC*(PCPU)**YEAUC*(PCAUC)           CYCLE/40
C72                                                                       CYCLE/45
      PCIU = (DPAO)**CEIUC*(DPIO)**PEIUC*(PCPU)**YEIUC*(PCIUC)           CYCLE/50
C73                                                                       CYCLE/55
      TCAA = (PCAA)*(PEA)                                                 CYCLE/60
C74                                                                       CYCLE/65
      TCAG = (PCAG)*(PEG)                                                 CYCLE/70
C75                                                                       CYCLE/75
      TCAK = (PCAK)*(POKI)                                                CYCLE/80
C76                                                                       CYCLE/85
      TCAI = (PCAI)*(PEI)                                                 CYCLE/90
C77                                                                       CYCLE/95
      TCAU = (PCAU)*(PU)                                                  CYCLES
C78                                                                       CYCLES 5
      TCIA = (PCIA)*(PEA)                                                 CYCLES10
C79                                                                       CYCLES15
      TCIG = (PCIG)*(PEG)                                                 CYCLES20
C80                                                                       CYCLES25
      TCIK = (PCIK)*(POKI)                                                CYCLES30
C81                                                                       CYCLES35
      TCII = (PCII)*(PEI)                                                 CYCLES40
C82                                                                       CYCLES45
      TCIU = (PCIU)*(PU)                                                  CYCLES50
C83                                                                       CYCLES55
      TCIO = TCIA + TCIG + TCIK + TCII + TCIU                             CYCLES60
C84                                                                       CYCLES65
      TCAO = TCAA + TCAG + TCAK + TCAI + TCAU                             CYCLES70
C85                                                                       CYCLES75
      EAOX = (OAS - TCAO)*(DPAO)                                          CYCLES80
C86                                                                       CYCLES85
      IF ((RICEX).LE.(OAS - TCAO))TXAX = (RICEX)*(RICEP)                  CYCLES90
      IF ((RICEX).GT.(OAS - TCAO))TXAX = (OAS - TCAO)*(RICEP)             CYCLES95
C87                                                                       CYCLET
      VIMI = (TCIO - OIS)*(DPIO)                                          CYCLET 5
C88                                                                       CYCLET10
      RG = TXAX + TXPEG + TXPKI + TXPEI + TXPEA + FAID                    CYCLET15
C89                                                                       CYCLET20
      EG = EGA + EGKI + YPEG                                              CYCLET25
C90                                                                       CYCLET30
      DSGA = RG - EG                                                      CYCLET35
C91                                                                       CYCLET40
      YTNE = YPEG + YPEA + YPEI + YKI                                     CYCLET45
C92                                                                       CYCLET50
      EXNE = EAOX + TPEM + EG                                             CYCLET55
C93                                                                       CYCLET60
      IMNE = VIMI + (RG - TXAX)                                           CYCLET65
```

```
C94
      BOPNE = EXNE - IMNE
C95
      ETNE = (TCIO)*(DPIO) + (TCAO)*(DPAO)
C96
      DYTNE = DYPEG + DYPEA + DYPEI + DYPKI + DYPU
C97
      YPCNE = YTNE / PT
C98
      EIOK = (TCIK)*(DPIO)
C99
      KIF = (KI)/(NFI)
      RETURN
  115 ERROR = ERROR + 1.
  114 ERROR = ERROR + 1.
  113 ERROR = ERROR + 1.
  112 ERROR = ERROR + 1.
  111 ERROR = ERROR + 1.
  110 ERROR = ERROR + 1.
  109 ERROR = ERROR + 1.
  108 ERROR = ERROR + 1.
  107 ERROR = ERROR + 1.
  106 ERROR = ERROR + 1.
  105 ERROR = ERROR + 1.
  104 ERROR = ERROR + 1.
  103 ERROR = ERROR + 1.
  102 ERROR = ERROR + 1.
  101 ERROR = ERROR + 1.
      RETURN
      END
$IBFTC POUT
      SUBROUTINE POUT
C
C          OUTPUT ROUTINE, PRINTS TABLE OF OUTPUT VALUES, ONE COLUMN
C          OUTPUT ROUTINE. PRINTS TABLE OF OUTPUT VALUES, ONE COLUMN
C          PER YEAR OF SIMULATION UNDER CONTROL OF INPUT CONTROL CARDS.
C
C          CALLED BY MAIN ROUTINE SPENT.  USES ROUTINE HEAD.
C
C
      COMMON /VC/  V(250)
      COMMON/AC/ A(20,250), NAME(250),PNAM(250),COMMET(20)
      COMMON/AC/  NVO,NY,NYT,NV,VAR,VALUE,NOF, NCOLP,NCYP,ICYP,ICOLP
      COMMON /HC/ NCASE, LINE
      REAL   NAME
C
C            PRINT OUTPUT MATRIX
C
      LINE = 0
      CALL HEAD
C
C            LOOP THRU LIST OF VARIABLES TO BE OUTPUT
      DO 30 I = 1,NVO
C
C            SET VARIABLE INDEX
      DO 10 J = 1,NV
      IF(NAME(J).EQ.PNAM(I)) GO TO 20
   10 CONTINUE
      WRITE(6,11) PNAM(I)
```

```
   11 FORMAT(1X,A6,21H CHECK VARIABLE NAME.)                          POUT 110
      GO TO 30                                                        POUT 115
C                                                                     POUT 120
C           PRINT ONE LINE OF OUTPUT (ONE VARIABLE)                   POUT 125
   20 WRITE(6,21) J,NAME(J),(A(L,J),L=1,NYT), V(J)                    POUT 130
   21 FORMAT(1H ,I3,1X,A6,7G16.9)                                     POUT 135
      LINE = LINE + 1                                                 POUT 140
      IF(LINE.LT.54) GO TO 30                                         POUT 145
C           FULL PAGE                                                 POUT 150
      CALL HEAD                                                       POUT 155
      N = 3                                                           POUT 160
      WRITE(6,26) N,NAME(3), (A(L,3),L=1,NYT),V(3)                    POUT 165
   26 FORMAT(1H ,I3,1X,A6,7G16.9)                                     POUT 170
   30 CONTINUE                                                        POUT 175
      RETURN                                                          POUT 180
      END                                                             POUT 185
$IBFTC HEAD
      SUBROUTINE HEAD                                                 HEAD   0
C                                                                     HEAD   2
C         PRINT HEADING AT TOP OF OUTPUT. CALLED BY SPENT AND POUT.   HEAD   3
C                                                                     HEAD   4
      COMMON /HC/ NCASE, LINE                                         HEAD   6
      LINE = 0                                                        HEAD  10
      WRITE(6,10) NCASE                                               HEAD  15
   10 FORMAT(1H1,40X,11HCASE NUMBER,I5/)                              HEAD  20
      RETURN                                                          HEAD  25
      END                                                             HEAD  30
$ENTRY          SPENT
OUT                        YEAR   CYOP
OUT                        DT     TEBS   YEAR   PEGB   INPEG  COASC1 COASC2 IGAC
OUT                        EGA    CIGA   KUAC1  KUAC2  KLB    LLRA   NFI    NFEKC
OUT                        NFEGC  MXRGP  PTBS   EGKI   CIGKI  APIKC  EIOK   CIKI
OUT                        KI     DRKI   KIEB   FPAO   RICEP  TCIO   FIONC1 FIONC2
OUT                        COIC1  COIC2  COIC3  COIC4  COIC5  OFIC3  OFIC1  OFIC2
OUT                        WDFC   WEGB   IWEGC  TPGAC  TPGUC  TXPGC  TPIAC  TPIUC
OUT                        TXPIC  TXPKC  TPAUC  TXPAC  TPEM   PEAAC  CEAAC  YEAAC
OUT                        PCAAC  CEIAC  PEIAC  YEIAC  PCIAC  PEAGC  CEAGC  YEAGC
OUT                        PCAGC  CEIGC  PEIGC  YEIGC  PCIGC  PEAKC  CEAKC  YEAKC
OUT                        PCAKC  CEIKC  PEIKC  YEIKC  PCIKC  PEAIC  CEAIC  YEAIC
OUT                        PCAIC  CEIIC  PEIIC  YEIIC  PCIIC  PEAUC  CEAUC  YEAUC
OUT                        PCAUC  CEIUC  PEIUC  YEIUC  PCIUC  RICEX  FAID
OUT                        DTT    TEBS   YEAR   PEG    COAS   IGLA   CIGA   KUA
OUT                        OAS    PEA    AFSP   AFSG   NFI    POKI   LIPBS  PT
OUT                        PAEI   IGKI   CIGKI  IKI    CIKI   DKI    CDKI   KI
OUT                        DPAO   VAO    YPEA   WEA    FION   OIS    OFI    PEI
OUT                        FAEI   WEI    MPPL   MRIO   OPIO   VIO    WEG    YPEG
OUT                        PU     TPGA   TPGU   TXPEG  DYPEG  YPEI   TPIA   TPIU
OUT                        TXPEI  DYPEI  YKI    TXPKI  DYPKI  TPAU   TXPEA  DYPEA
OUT                        DYPU   PCPEA  PCAA   PCIA   PCPEG  PCAG   PCIG   PCPKI
OUT                        PCAK   PCIK   PCPEI  PCAI   PCII   PCPU   PCAU   PCIU
OUT                        TCAA   TCAG   TCAK   TCAI   TCAU   TCIA   TCIG   TCIK
OUT                        TCII   TCIU   TCIU   TCAO   EAOX   TXAX   VIMI   RG
OUT                        EG     DSGA   YTNE   EXNE   IMNE   BOPNE  ETNE   DYTNE
OUT                        YPCNE  EIOK   TXPEI  PCIK   PCAI   CHECK  ERROR
OUT                        TCIC1  TCIC2  TCIAV  EGAC   EGKIC  EGKIC1 EGAC1
OUT                        WEIAV  WEIC1  WEIC2  KIF
  1 DT     10.0                                                       VARIN  5
  2 TEBS  0.0                                                         VARIN 10
  3 YEAR  1960.                                                       VARIN 15
  4 PEG   0.                                                          VARIN 20
```

```
 5 INPEG 0.1                                                     VARIN 25
 6 COASC10.11053044                                              VARIN 30
 7 COASC20.01                                                    VARIN 35
 8 IGAC  0.0001                                                  VARIN 40
 9 EGA   0.0                                                     VARIN 45
10 CIGA  10000000.                                               VARIN 50
11 KUAC1 0.7142857                                               VARIN 55
12 KUAC2 0.04186                                                 VARIN 60
13 KLB   110000000.                                              VARIN 65
14 LLRA  0.11985764                                              VARIN 70
15 NFI   9847.                                                   VARIN 75
16 NFEKC 0.0[illegible]                                          VARIN 80
17 NFEGC 0.005                                                   VARIN 85
18 MXRGP 0.03                                                    VARIN 90
19 PTBS  9021543.                                                VARIN 95
20 EGKI  0.0                                                     VARIN100
21 CIGKI 0.                                                      VARIN105
22 APIKC 0.05                                                    VARIN110
23 EIDK  214577200.                                              VARIN115
24 CIKI  0                                                       VARIN120
25 KI    2357953000.                                             VARIN125
26 DRKI  0.004550075                                             VARIN130
27 KIEB  2357953000.                                             VARIN135
28 FPAO  1460.                                                   VARIN140
29 RICEP 585.                                                    VARIN145
30 TCIO  268961880.                                              VARIN150
31 FIDNC10.3506747                                               VARIN155
32 FIDNC20.0                                                     VARIN160
33 COIC1 9578.361                                                VARIN165
34 COIC2 1.0                                                     VARIN170
35 COIC3 0.02                                                    VARIN175
36 COIC4 1.0                                                     VARIN180
37 COIC5 0.01                                                    VARIN185
38 DFIC3 2720.072                                                VARIN190
39 DFIC1 0.5                                                     VARIN195
40 DFIC2 0.5                                                     VARIN200
41 WDFC  0.1909750                                               VARIN205
42 WEGB  2460.                                                   VARIN210
43 IWEGC 0.03                                                    VARIN215
44 TPGAC 0.00655036                                              VARIN220
45 TPGUC 0.03                                                    VARIN225
46 TXPGC 28.97777                                                VARIN230
47 TPIAC 0.0164029                                               VARIN235
48 TPIUC 0.03                                                    VARIN240
49 TXPIC 28.97777                                                VARIN245
50 TXPKC 0.022                                                   VARIN250
51 TPAUC 0.26002483                                              VARIN255
52 TXPAC 2.033898                                                VARIN260
53 TPEM  154846200.                                              VARIN265
54 PEAAC -0.8                                                    VARIN270
55 CEAAC -0.1                                                    VARIN275
56 YEAAC 0.9                                                     VARIN280
57 PCAAC 0.4395051                                               VARIN285
58 CEIAC 0.1                                                     VARIN290
59 PEIAC -1.2                                                    VARIN295
60 YEIAC 1.1                                                     VARIN300
61 PCIAC 0.1269659                                               VARIN305
62 PEAGC -0.8                                                    VARIN310
63 CEAGC -0.1                                                    VARIN315
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 64 YEAGC 0.9                                   VARIN320
 65 PCAGC 0.4680065                             VARIN325
 66 CEIGC 0.1                                   VARIN330
 67 PEIGC -1.2                                  VARIN335
 68 YEIGC 1.1                                   VARIN340
 69 PCIGC 0.1237957                             VARIN345
 70 PEAKC -0.8                                  VARIN350
 71 CEAKC -0.1                                  VARIN355
 72 YEAKC 0.9                                   VARIN360
 73 PCAKC 0.5091140                             VARIN365
 74 CEIKC 0.1                                   VARIN370
 75 PEIKC -1.2                                  VARIN375
 76 YEIKC 1.1                                   VARIN380
 77 PCIKC 0.1237957                             VARIN385
 78 PEAIC -0.8                                  VARIN390
 79 CEAIC -0.1                                  VARIN395
 80 YEAIC 0.9                                   VARIN400
 81 PCAIC 0.4577043                             VARIN405
 82 CEIIC 0.1                                   VARIN410
 83 PEIIC -1.2                                  VARIN415
 84 YEIIC 1.1                                   VARIN420
 85 PCIIC 0.1237957                             VARIN425
 86 PEAUC -0.8                                  VARIN430
 87 CEAUC -0.1                                  VARIN435
 88 YEAUC 0.9                                   VARIN440
 89 PCAUC 0.4198889                             VARIN445
 90 CEIUC 0.1                                   VARIN450
 91 PEIUC -1.2                                  VARIN455
 92 YEIUC 1.1                                   VARIN460
 93 PCIUC 0.1237957                             VARIN465
 94 RICEX 600000.                               VARIN470
 95 FAID  100000000.                            VARIN475
 96 PT                                          VARIN480
 97 PEA                                         VARIN485
 98 PEI                                         VARIN490
 99 PDKI                                        VARIN495
100 PU                                          VARIN500
101 WEA                                         VARIN505
102 WEI                                         VARIN510
103 WEG                                         VARIN515
104 DPIO                                        VARIN520
105 KUA                                         VARIN525
106 OAS                                         VARIN530
107 AFSP                                        VARIN535
108 AFSG                                        VARIN540
109 CDKI                                        VARIN545
110 OFI                                         VARIN550
111 OIS                                         VARIN555
112 MPPL                                        VARIN560
113 TPGA                                        VARIN565
114 TPGU                                        VARIN570
115 YPEA                                        VARIN575
116 YPEG                                        VARIN580
117 YKI                                         VARIN585
118 PCPEA                                       VARIN590
119 PCPEG                                       VARIN595
120 PCPKI                                       VARIN600
121 PCPEI                                       VARIN605
122 PCPU                                        VARIN610
123 TCAU                                        VARIN615
```

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124 EAOX                                                    VARIN620
125 TXAX                                                    VARIN625
126 VIMI                                                    VARIN630
127 RG                                                      VARIN635
128 EG                                                      VARIN640
129 DSGA                                                    VARIN645
130 YTNE                                                    VARIN650
131 EXNE                                                    VARIN655
132 IMNE                                                    VARIN660
133 BOPNE                                                   VARIN665
134 ETNE                                                    VARIN670
135 DYTNE                                                   VARIN675
136 YPCNE                                                   VARIN680
137 COAS                                                    VARIN685
138 IGLA                                                    VARIN690
139 LIPBS                                                   VARIN695
140 PAEI                                                    VARIN700
141 IGKI                                                    VARIN705
142 IKI                                                     VARIN710
143 DKI                                                     VARIN715
144 DPAO                                                    VARIN720
145 VAO                                                     VARIN725
146 FION                                                    VARIN730
147 FAEI                                                    VARIN735
148 MRIO                                                    VARIN740
149 DPZZ                                                    VARIN745
150 VIO                                                     VARIN750
151 TXPEG                                                   VARIN755
152 DYPEG                                                   VARIN760
153 YPEI                                                    VARIN765
155 COLP  25.                                               VARIN770
156 CYP   10.                                               VARIN775
157 CYOP  0.                                                VARIN780
158 DTT        0.0                                          VARIN785
159 CNYT    6.0                                             VARIN790
160 TCAG                                                    VARIN795
161 TCAI                                                    VARIN800
162 TCIK                                                    VARIN805
163 PEAU                                                    VARIN810
164 PCAK                                                    VARIN815
165 TXPEA                                                   VARIN820
166 TCAK                                                    VARIN825
167 TCAO                                                    VARIN830
168 TPGZZ      0.                                           VARIN835
169 PCIU                                                    VARIN840
170 IZZZ                                                    VARIN845
171 DYPEA                                                   VARIN850
172 TCIU                                                    VARIN855
173 PCAU                                                    VARIN860
174 TXPKI                                                   VARIN865
175 PEGB  237807.                                           VARIN870
176 TPIU                                                    VARIN875
177 PCIA                                                    VARIN880
178 DYPEI                                                   VARIN885
179 TCIA                                                    VARIN890
180 PCIG                                                    VARIN895
181 TPAU                                                    VARIN900
182 PCAA                                                    VARIN905
183 PCII                                                    VARIN910
```

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184 TPIA                                                  VARIN915
185 TCIG                                                  VARIN920
186 TCAA                                                  VARIN925
187 PCAG                                                  VARIN930
188 DYPU                                                  VARIN935
189 DYPKI                                                 VARIN940
190 TCII                                                  VARIN945
191 TXPEI                                                 VARIN950
192 PCIK                                                  VARIN955
193 PCAI                                                  VARIN960
194 CHECK                                                 VARIN965
195 ERROR                                                 VARIN970
196 TCIC1   .9                                            VARIN975
197 TCIC2   .1                                            VARIN980
198 TCIAV 268961880.                                      VARIN985
199 EGAC  0.1                                             VARIN990
200 EGKIC 0.1                                             VARIN995
201 EGKIC1166000000.                                      VARIN/ 5
202 EGAC1 180000000.                                      VARIN/10
203 WEIAV 1550.                                           VARIN/15
204 WEIC1 0.9                                             VARIN/20
205 WEIC2 0.1                                             VARIN/25
206 KIF                                                   VARIN/30
END
```

Appendix B

COMPUTER PROGRAM DESCRIPTION

IDENTIFICATION

SPENT - Simulation Program of the Economy of North East Thailand

IBM 7040/7044

FORTRAN IV coded program

Charles Bush: December 27, 1966.

PURPOSE

To simulate the major economic trends of Northeast Thailand by iterative evaluation, thru time, of a set of mathematical equations.

USAGE

A standard program package will be supplied to the reader on request. It is the complete program setup for running a stabilized simulation and outputing of all variable values for each year of a 25 year period starting with 1960.

Changes can be made by the user to run variations of the standard run. These variations are described below. Note that some of these changes require a knowledge of FORTRAN IV.

1. To run the standard case with different initial values: Find the variable name in the initial value list and change the value as desired.

Cols. 1-3	Variable index (can be blank).
Cols. 5-10	Variable name.
Cols. 11-22	Variable value. Decimal point must always be present. If value is larger than $9x10^{10}$ a FORTRAN format description may be punched into Cols. 23-35 to describe Cols. 11-22.
Cols. 36-80	Comments.

2. To run more than one simulation case:
   Place initial value cards for additional cases at the end of the input deck followed by an end of case card (END in Cols. 1-3). Only those initial values that are different from the initial values of the preceding case need be included.

3. To change the number and order of output variables:
   Include with the initial value cards output control cards of the following format:

   OUTPUT CONTROL CARD FORMAT:

   Cols. 1-3 "OUT"

   Cols. 23-78 Eight variables name fields of seven columns each.

   These cards must be grouped together. Until a new group is read in, they will control the output. The variables will be output down the page as they appear left to right, top to bottom, on the control cards.

4. The simulation equations may be changed and new ones added at the discretion of the user. Any new variables must be defined as described in Section 5 if the values are to be output.

5. To define a new variable name:
   Add the new name to the end of the common and data block.
   Restrictions:
   a. Names in common and data block must be in the same order.
   b. A maximum of 250 names are allowed.
   c. All names must be in floating point mode conforming to standard FORTRAN naming conventions.

6. The initial value cards for the following variables are used to control the simulation and may be changed by the user.

   YEAR - Initial simulation year.

   DT - Simulation time increment (hundredths of a year).

CYP - Number of simulation iterations per output iteration.

COLP - Number of output iterations.

CNYT - Number of columns across a page (maximum of six).

COMPUTER RUN ESTIMATES

These statistics are for the standard case and will naturally be affected by user variations.

25 pages per case.

35 seconds per case.

1 minute and 10 pages of overhead.

Program size - 16K.

ERROR CONDITIONS

A simulation run may be terminated before completion if impossible economic conditions arise. The reason for termination may be determined by referring to the last output value for the variable ERROR. A zero value indicates there was no error.

ERROR value		Variable causing error
1	-	CHECK
2	-	DPAO
3	-	DPIO
4	-	PCPEA
5	-	PCPEG
6	-	PCPKI
7	-	PCPEI
8	-	PCPU

PRINTOUT FORMAT

As the input cards for a simulation case are read, they are printed. If a variable is undefined, a message will be printed. Following the input printout the results of the simulation are printed. Results are printed in the form of a table of variable

values for each year of the simulation. From left to right the print-out columns are:

Column 1 - Variable index.
2 - Variable name.
3 - Initial simulation values.
4 to next to last - Intermediate values.
Last column - Variable values at termination. These will be the same as the column to the left for a successful run.

METHOD

In a typical computer run the user inputs initial values describing the economy for a base year. The program, after reading these values, executes the simulation starting from the base year and outputs the new values describing the economy for each year of the simulation. Having completed the simulation, the user will want to change a few specific initial values and rerun the simulation to observe the effect of changes. This is accomplished with the same computer run by indicating to the program (with a special flag card) that the preceding cards complete a simulation and any following cards are for a new simulation. The program will read new initial values and repeat the simulation using initial values from the preceding simulation or new values. The user may run as many simulations as desired by repeating the sequence of initial values and flag card.

The program consists of a main control routine, called SPENT, which executes the simulation routine, called CYCLE, and an output routine, called POUT. SPENT does inputing and increments the simulation clock. With each increment of time SPENT executes CYCLE. CYCLE consists of approximately one hundred equations that are the description of the economy. SPENT executes the output routine POUT whenever storage is filled or the simulation is terminated.

The user has some control over the contents and form of the output through use of special output format cards which are input with initial value cards.

Appendix C

AN ALTERNATIVE APPROACH: AN OPTIMAL GROWTH MODEL

To most economists, a simulation model of economic growth will be less familiar than an analytic model. What the simulation model gains in realism, it loses in optimality: unlike the analytic model, the simulation model cannot be manipulated mathematically to reveal the best program.

It might be useful, therefore, to formulate a model that is as nearly like our simulation model of the economy of the Northeast of Thailand as possible and yet is capable of being solved mathematically so as to reveal its general properties. Our point of departure will be the models of Kurz [491], Stoleru [460], and Bose [501], all of which depict a development strategy whose aim is the most speedy elimination of unemployment. Our advance will be in two directions: one the inclusion of technological progress, and the other the consideration of alternative optimality criteria.

THE STRUCTURE OF THE OPTIMAL GROWTH MODEL

Retaining our mnemonic script, the terms in the model will be the following:

	Traditional Sector	Modern Sector	Whole Economy
Variables			
Output	ØAS	ØIS	TØ
Capital stock	KUA	KI	-
Labor employed	PEA	PEI	-
Labor unemployed	-	-	PU
Total labor	-	-	PT
Time elapsed	-	-	TEBS
Parameters			
Output: capital coefficient	CØAS	CØIS	-
Output: labor coefficient	LØAS	LØIS	-
Growth of productivity of capital	GPKA	GPKI	-

	Traditional Sector	Modern Sector	Whole Economy
Parameters (continued)			
Growth of productivity of labor	GPLA	GPLI	-
Depreciation rate of capital	DRKA	DRKI	-
Growth of the labor force	-	-	LNPT
Natural logarithm (e=2.71)	-	-	EXP
Instruments			
Savings rate	-	APIKC	-
Allocation of investment	(1-EGKIC)	EGKIC	-

The majority of these terms appear in the simulation model too, although several of them have different dimensions or coverage. We have tried to keep the differences to a minimum.

The structure of the growth model is as follows: production in each of the two sectors takes place with the factors combined in fixed proportions:

$$\text{ØAS} = \text{MIN} \begin{cases} (\text{CØAS}) * (\text{KUA}) * \text{EXP}\ (\text{GPKA} * \text{TEBS}) \\ (\text{LØAS}) * (\text{PEA}) * \text{EXP}\ (\text{GPLA} * \text{TEBS}) \end{cases} \tag{1}$$

$$\text{ØIS} = \text{MIN} \begin{cases} (\text{CØIS}) * (\text{KI}) * \text{EXP}\ (\text{GPKI} * \text{TEBS}) \\ (\text{LØIS}) * (\text{PEI}) * \text{EXP}\ (\text{GPLI} * \text{TEBS}) \end{cases} . \tag{2}$$

Capital will be assumed to grow through savings in the modern sector only, labor inevitably through the passage of time; capital to be mobile before allocation to either sector but immobile thereafter, and labor to be mobile at all times.

The growth of the stock of capital in the traditional and modern sectors will be equal to the amount allocated to them, less their depreciation:

$$\frac{\text{D(KUA)}}{\text{DT}} = (1 - \text{EGKIC})\ (\text{APIKC})\ (\text{ØIS}) - (\text{DRKA})\ (\text{KUA}) \tag{3}$$

$$\frac{D(KI)}{DT} = (EGKIC)\ (APIKC)\ (\emptyset IS) - (DRKI)\ (KI)\ . \tag{4}$$

The net growth of the labor force is:

$$\frac{D(PT)}{DT} = LNPT\ (PT)\ . \tag{5}$$

The total labor force is composed of those employed in each sector and those without employment:

$$PT = PEA + PEI + PU\ . \tag{6}$$

On the assumption of capital scarcity, which our simulation results indicate (for at least a generation), the numbers of employed in each sector can be derived from equations (1) and (2):

$$PEA = \left(\frac{C\emptyset AS}{L\emptyset AS}\right)\ (KUA)\ {*EXP}\ [(GPKA-GPLA)\ TEBS] \tag{7}$$

$$PEI = \left(\frac{C\emptyset IS}{L\emptyset IS}\right)\ (KI)\ {*EXP}\ [(GPKI-GPLI)\ TEBS]\ . \tag{8}$$

These in turn can be substituted into equation (6), leaving PU expressed in terms of PT, KUA, and KI:

$$\begin{aligned} PU = PT &- \left(\frac{C\emptyset AS}{L\emptyset AS}\right)\ (KUA)\ {*EXP}\ [(GPKA-GPLA)\ TEBS] \\ &- \left(\frac{C\emptyset IS}{L\emptyset IS}\right)\ (KI)\ {*EXP}\ [(GPKI-GPLI)\ TEBS], \qquad PU \geq 0\ . \end{aligned} \tag{9}$$

But equations (7), (8), and (9) are incidental and hopefully transitory; the structure of the model is complete with equations (1) and (2), measuring output in the two sectors; equations (3) and (4), measuring net investment; equation (5), measuring the rate of growth of the labor force; and equation (6), measuring the level of unemployment.

TRAJECTORIES OF CAPITAL FORMATION

Initially there is not enough capital to occupy all the labor in the Northeast. Employment and output are constrained by the capital stock, and will increase only as it does. Consequently our mathematical analysis will be directed at the scarce factor, capital. The procedure will be as follows: first we shall transform the equations of capital formation so as to manipulate them more easily; second, we shall collect some of the parameters so as to simplify the appearance of the results; third, we shall solve the equations for capital formation so as to determine the feasible growth paths in the two sectors; fourth, from among all feasible growth paths and according to certain criteria we shall choose the optimal paths by utilizing the appropriate shadow prices; and finally, we shall illustrate, with the economy of the Northeast of Thailand, how the optimal paths differ with different objectives.

In the first step we transform equations (3) and (4) so that the left hand terms are expressed as the rate of growth of capital per unit of effective labor, the effectiveness of labor rising with increases in its productivity in the modern sector through technological progress. The transformed variables, K1 and K2 (the 1 and 2 standing for the modern and traditional sectors respectively), are both functions of time and are defined as:

$$\text{K1} = \text{KI}/(\text{PT})\ \text{EXP}\ (\text{GPLI} * \text{TEBS}) \tag{10}$$

and

$$\text{K2} = \text{KUA}/(\text{PT})\ \text{EXP}\ (\text{GPLI} * \text{TEBS})\ . \tag{11}$$

Second, to simplify the expressions we shall define four additional parameters:

$$\text{A1} = (\text{C}\emptyset\text{IS})\ \text{EXP}\ (\text{GPKI} * \text{TEBS}) \tag{12}$$

$$A2 = (C\emptyset AS)\ EXP\ (GPKA * TEBS) \qquad (13)$$

$$B1 = DRKI + GPLI + LNPT \qquad (14)$$

$$B2 = DRKA + GPLA + LNPT\ . \qquad (15)$$

A1 and A2 are the output: capital ratios for the two sectors, each augmented by the capital component of technological progress. B1 and B2 are the sums of the rates of depreciation, of labor augmentation and of growth of population in the two sectors; they can be interpreted as the rates of investment necessary, in equilibrium, to employ fully the (growing) labor force.

With definitions (10) through (15) the equations for capital formation, (3) and (4), can be rewritten as:

$$\frac{D(K1)}{DT} = (A1)\ (EGKIC)\ (APIKC) - (B1)\ (K1) \qquad (16)$$

and

$$\frac{D(K2)}{DT} = (A1)\ (1 - EGKIC)\ (APIKC)\ (K1) - (B2)\ (K2)\ . \qquad (17)$$

Equations (16) and (17) are first-order differential equations with nonconstant coefficients. Their solutions through time are the pair of parametric equations

$$K1\text{-}TEBS = \Big[EXP \int_{1960}^{TEBS} (A1)\ (EGKIC)\ (APIKC)\ DC - (B1)\ (TEBS)\Big]\ (K1\text{-}1960) \qquad (18)$$

and

$$\text{K2-TEBS} = \left[\int_{1960}^{\text{TEBS}} (\text{A1})\ (1 - \text{EGKIC})\ (\text{APIKC}) \right]$$

$$\text{EXP}\ [(\text{B2}*\ (\text{C} - \text{TEBS})\ \text{DC}]\ (\text{K1-1960}) \qquad (19)$$

$$+ \text{EXP}\ (-\ \text{B2}\ *\text{TEBS})\ (\text{K2-1960})$$

where $\int$DC are indefinite integrals and K1-1960 and K2-1960 stand for the initial stocks of capital in the two sectors.

Equations (18) and (19) yield the trajectories of capital formation. The capital stock in the modern sector (K1) will grow or shrink exponentially depending upon whether (A1) (EGKIC) (APIKC) exceeds or is less than (B1), that is, upon whether the rate at which new capital is being provided is more or less than the rate at which the need for it increases. The capital stock in the traditional sector (K2) similarly will grow or shrink, depending upon whether or not the replenishments from the modern sector are more or less than the needs that arise in the traditional.

The capital trajectories for the sets of conditions most likely to be encountered in real economies are displayed in the phase diagrams, Figs. C-1, C-2, and C-3. Their axes are K1 and K2, the capital stocks, per capita, in each of the two sectors. Three reference lines, drawn with dashes, appear in each phase diagram: the first, labeled ELAS = 1, is the "shed line" (representing equal rates of growth or decline of capital stocks, per capita, in both sectors), which all trajectories approach asymptotically. The second, labeled $\frac{D(K2)}{DT} = 0$, is the locus of combinations of K1 and K2 which just maintain the capital stock, per capita, in the traditional sector. The third reference line, FE, is the locus of the various quantities of K1 and K2 that employ fully the available labor force: given our assumption of fixed factor coefficients in production, trajectories to the northeast of the full employment line are not physically possible.

Fig. C-1

(A1)(EGKIC)(APIKC) > B1

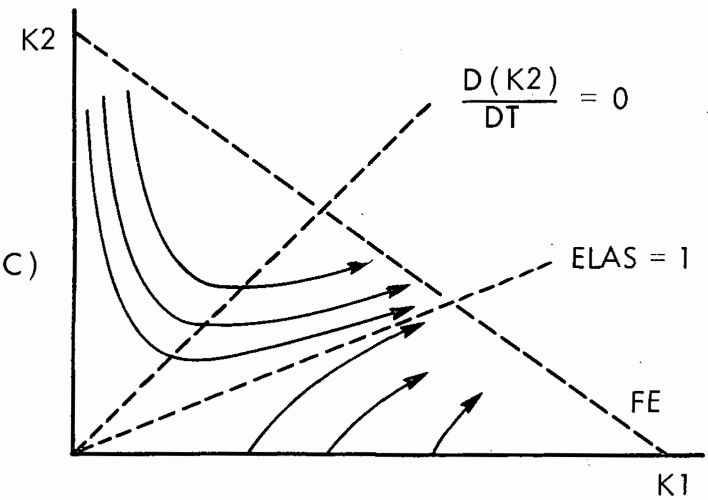


Fig. C-2

(A1)(EGKIC)(APIKC) = B1

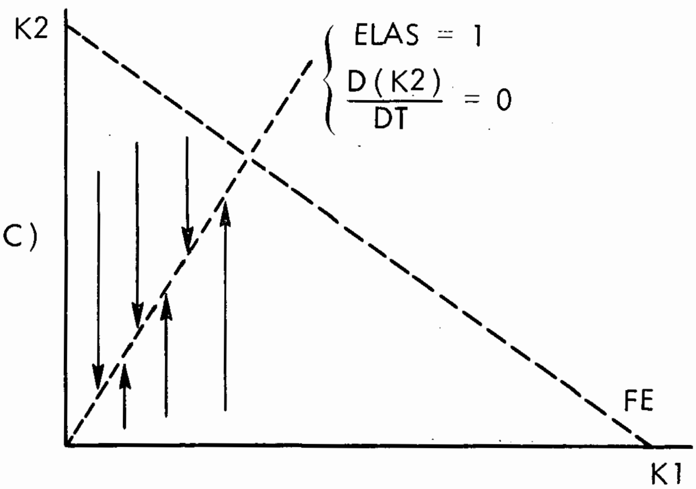
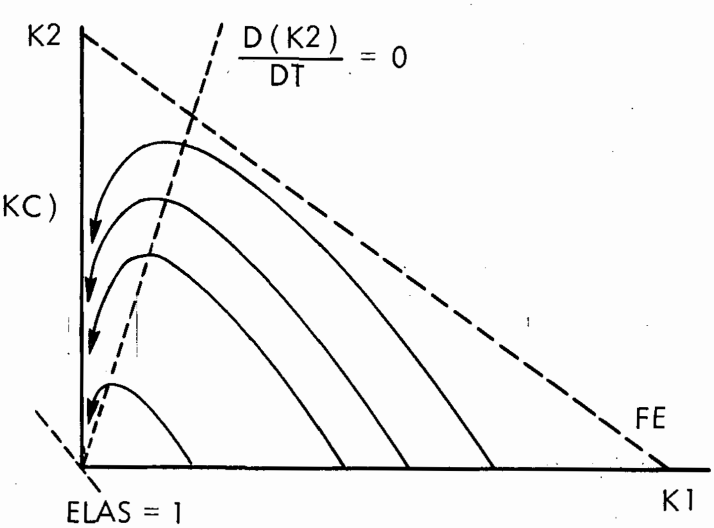


Fig. C-3

(A1)(EGKIC)(APIKC) - B1 + B2 < 0



Trajectories for capital stocks, per capita, in the optimal growth model

Did our model not include technological progress in capital, the three reference lines would remain fixed in the phase diagram throughout time (as they do, for example, in Bose's model [501]). But our model does permit improvements in the productivity of capital, and so all three will move, the first and second rotating counter-clockwise, and the third falling in towards the origin, with the passage of time.

Which trajectory is followed depends upon the initial endowment of capital per capita (as indicated by the coordinates of the initial point in the phase diagram) and the values of the four parameters A1 (the augmented output: capital ratio), EGKIC (the fraction of investment allocated to the modern sector), APIKC (the savings rate), and B1 (the rate of growth of the need for investment in the modern sector). When B1 is less than the product (A1) (EGKIC) (APIKC), the capital stock in the modern sector grows exponentially, according to equation (18): this is the situation depicted in the phase diagram C-1. When B1 is exactly equal to (A1) (EGKIC) (APIKC), the trajectories are the vertical lines of phase diagram C-2. In this special case the shed line and the line $\frac{D(K2)}{DT} = 0$ coincide; once on this line the economy has reached a state of balanced growth, at a rate equal to the increase in the (augmented) labor force.

When B1 is greater than (A1) (EGKIC) (APIKC), and when B2 is not so large as to prevent (at least for a while) capital being accumulated in the traditional sector (precisely, when (A1) (EGKIC) (APIKC) - B1 + B2 < 0) phase diagram C-3 is applicable. In this figure, the shed line lies outside the positive orthant, revealing that the capital stock, per capita, in the traditional sector never declines at a rate quite so fast as that in the modern sector.

THE OBJECTIVE OF GROWTH

From which point in the phase diagram the capital stocks begin their trajectory depends upon the endowment of the economy at the initial point in time. Along which trajectory they ride depends upon which development strategy is chosen. If, for example, the sole aim

is to accumulate capital in the modern sector, the strategy will be to save as much as possible and to allocate as high as possible a fraction of the subsequent investment to the modern sector. In terms of equations (16) and (17) this strategy is equivalent to maximizing both EGKIC and APIKC; in terms of the phase diagrams it is, for the abstemious economy, equivalent to following a trajectory in Fig. C-1.

The antithetic strategy of increasing as quickly as possible the capital stock in the traditional sector will require maximizing APIKC, the savings rate, as above, but minimizing EGKIC, the fraction allocated to the modern sector. In this case, the trajectory of capital development is most likely to be of the direction of those in Fig. C-3.

Other objectives might require different values of the savings rate and the allocation parameter -- those instruments assumed to be under the control of and imposed by society in order to achieve its economic goals. It is possible that the optimum policy would involve varying the controls during the process of growth, from say a maximum value of EGKIC throughout the first epoch to a minimum value throughout the second.

In the text of our study of the economy of the Northeast of Thailand we deduced that rising unemployment would be a phenomenon of the 1960s and 1970s, the reasons being the almost simultaneous fall in the death rate, the increase in the birth rate, and the exhaustion of the supply of virgin land. It would seem appropriate, therefore, that we set as our objective the speedy elimination of unemployment. In terms of our model this is equivalent to finding for the policy instruments those values that will minimize the time to full employment of labor.

The equation for full employment can be devised by setting equal each half of equation (1), and each half of equation (2), and by adding the two equalities together. This yields

$$\left(\frac{A1}{L\O IS}\right)(K1) + \left(\frac{A2}{L\O AS}\right)(K2)\ EXP\ [(GPLI-GPLA)*TEBS] = 1 \qquad (20)$$

where A1, A2, K1, and K2 are the transformed variables defined in identities (10) through (13).

Once the economy achieves full employment the equations describing the trajectories of capital [equations (18) and (19)] no longer apply, for both factors, rather than capital alone, are in short supply. A different solution, meeting a new criterion, must be generated. We shall therefore halt our analysis of the growth properties of the model of the economy of the Northeast when full employment has been attained.

Just as we expressed the equation for full employment in terms of the transformed variables, so can we express the objective function in the same terms. In its most general form it would be

$$\text{OBJ} = \text{OBJ}\ (\text{K1, K2, EGKIC, APIKC, TEBS}) \tag{21}$$

with OBJ signifying the aim to be achieved and the arguments consisting of the transformed capital stocks, per capita, the policy instruments, and time.

In order to determine the optimal policy for this general objective function we set up the Hamiltonian function, H,

$$\text{H} = \text{OBJ} + (\text{P1})\ \frac{\text{D(K1)}}{\text{DT}} + (\text{P2})\ \frac{\text{D(K2)}}{\text{DT}} \tag{22}$$

in which P1 and P2 are the shadow prices of capital allocated to the two sectors. The rates of change of the capital stock, per capita, have already been determined in equations (16) and (17), and can be substituted for the terms $\frac{\text{D(K1)}}{\text{DT}}$ and $\frac{\text{D(K2)}}{\text{DT}}$.

We wish to maximize the Hamiltonian function for all times, and will do so by selecting the optimum set of controls EGKIC and APIKC. If we take the partial derivatives of the Hamiltonian with respect to the shadow prices we generate an equation system whose constraints are the differential equations for capital, equations (16) and (17). (This is equivalent to differentiating with respect to the state

variables in a Lagrangian system, where EGKIC and APIKC are the state variables.) If we guess at values of the optimum controls, we can apply the Pontryagin conditions; these combined with the initial values of the variables K1 and K2 force the shadow prices to evolve in such a way as to permit the proper amount and assignment of new capital.

Along the optimum path the partial derivatives of the Hamiltonian function with respect to the controls will be set equal to zero (provided that there is a maximum for the Hamiltonian throughout). This yields, from equation (22), one equation for each control:

$$\frac{\partial(H)}{\partial(EGKIC)} = \frac{\partial(OBJ)}{\partial(EGKIC)} + (P1 - P2)\ (A1)\ (APIKC)\ (K1) \tag{23}$$

and

$$\frac{\partial(H)}{\partial(APIKC)} = \frac{\partial(OBJ)}{\partial(APIKC)} + [(EGKIC)\ (P1) + (1\text{-}EGKIC)\ (P2)]\ (A1)\ (K1). \tag{24}$$

MINIMUM TIME TO FULL EMPLOYMENT

Equations (23) and (24) will become precise when we specify the objective function. Since we have established as a goal the speedy elimination of unemployment, the objective function will encompass this aim. Fortunately for the analysis the objective function is simple, the interval to full employment being minimized when

$$OBJ = -1 \tag{25}$$

With the objective function (25) the partial derivatives of the Hamiltonian function become

$$\frac{\partial H}{\partial(EGKIC)} = (P1\text{-}P2)\ (A1)\ (APIKC)\ (K1) \tag{26}$$

and

$$\frac{\partial H}{\partial (APIKC)} = [(EGKIC)\ (P1) - (1\text{-}EGKIC)\ (P2)]\ (A1)\ (K1) \tag{27}$$

and the differential equations for the shadow prices

$$\frac{D(P1)}{DT} = -\ [(A1)\ (EGKIC)\ (APIKC) - B1)]\ (P1) - (A1)\ (1\text{-}EGKIC)\ (APIKC)\ (P2) \tag{28}$$

and

$$\frac{D(P2)}{DT} = -\ (B2)\ (P2) \tag{29}$$

The shadow prices, P1 and P2, will change through time; P1 commencing higher than P2 and declining, P2 rising. So long as P1 exceeds P2, as much as possible of the capital created in the modern sector will be retained in that sector, in order to build up its capacity. When P2 equals P1, that is, when the shadow price of new capital allocated to the traditional sector equals the shadow price of new capital allocated to the modern sector, the "switch point" will have been reached: thereafter as much as possible of the capital created in the modern sector will be allocated to the traditional sector, in order to absorb the unemployed labor. This second regime will persist until full employment has been attained.

Summarizing the optimum policy for the minimum interval to full employment, the savings rate (APIKC) is maximized throughout, and the fraction of total investment allocated to the modern sector (EGKIC) is maximized from the initial point in time to the switch point and minimized from the switch point till the end. Economically this results first in the capital stock of the modern sector, where each unit of capital can generate more investment, being built up to the point where it is sufficiently large both to sustain itself and to also provide increments for the traditional sector; and second in the capital stock of the modern sector being used to supply substantial new capital for the traditional sector, where each unit of capital can generate more

employment. The trajectories that will be followed by the capital stocks, per capita, will be a sequence of part of one of Fig. C-1 (depicting the accumulation of capital in the modern sector) and part of one of Fig. C-3 (depicting the accumulation of capital in the traditional). The changeover from a trajectory of the type drawn in Fig. C-1 to the type in C-3 will occur at the switch point.

THE CASE OF THE NORTHEAST OF THAILAND

We have solved our system of equations (16) and (17) for the objective, specified in equation (20), to be obtained in the minimum time, according to equation (25). When solved, the formulae for the shadow prices, equations (28) and (29), indicate when to switch from the first regime (APIKC maximum; EGKIC maximum) to the second (APIKC maximum; EGKIC minimum). We shall now substitute, for the variables in the model, values of the initial capital stocks, of the production parameters, and of the policy instruments appropriate for the economy of the Northeast. These values have been estimated from the *tableau économique* presented in Section VIII. Some have been taken over almost without change, for example, the initial capital stocks, per capita, and the rates of increase of productivity of the factors of production. Others incorporate within a single coefficient what are several functions in the simulation model, such as the output: capital and the output; labor ratios; and still others which are the author's guesses (for example, the upper and lower bounds of the policy instruments). All appear in Table C-1.

The endowments of capital and labor in 1960, when expressed in terms of K1 and K2, the transformed variables, yield the coordinates of the initial point within the phase diagram. Since K1 = .33 and K2 = 3.57, the economy starts its trajectory in the northwestern portion of the positive orthant, close to the full employment line. The first trajectory followed is of the type drawn in Fig. C-1, for which savings are maximized and as much new capital as possible is allocated to the modern sector. The trajectory moves southeastwards in the phase plane, indicating that while the capital stock, per

Table C-1

PARAMETER VALUES AND INITIAL CONDITIONS FOR THE OPTIMAL GROWTH MODEL DEPICTING THE ECONOMY OF THE NORTHEAST

	Modern Sector	Traditional Sector	Entire Region
Parameters			
Output: capital ratio (CØ-S; baht per baht)	0.4	0.25	-
Output: labor ratio (LØ-S; 8.3×10^2 baht per person)[a]	2.0	1.0	-
Growth of productivity of capital (GPK-; fraction per year)	0.03	0.02	-
Growth of productivity of labor (GPL-; fraction per year)	0.06	0.02	-
Depreciation rate of capital (DRK-; fraction per year)	0.05	0.05	-
Rate of growth of the labor force (LNPT; fraction per year)	-	-	0.03
Instruments			
Savings rate (APIKC)			
maximum	0.5	-	-
minimum	0.3	-	-
Allocation of investment (EGKIC)			
maximum to modern sector	0.9	0.1	-
maximum to traditional sector	0.3	0.7	-
Initial Conditions			
Capital stock (KI, KUA; 8.3×10^2 in baht)[a]	2.9×10^6	32×10^6	35×10^6
Labor force (PT; persons)	-	-	9×10^6
Labor employed (PE-; persons)	0.6×10^6	8×10^6	8.6×10^6
Labor unemployed (PU; persons)	-	-	0.4×10^6
Year	-	-	1960
Transformed initial conditions and parameters			
Capital stock per capita (K1, K2; 8.3×10^2 baht per person)[a]	0.33	3.57	3.9
Growth of need for new capital (B1, B2; fraction per year)	0.14	0.09	-

Note:

[a]In order to keep the output: labor ratios in the two sectors integers (2.0 and 1.0), the ratios in value terms had to be divided by 8.3×10^2.

capita, in the modern sector is being built up, the capital stock, per capita, in the traditional sector is being drawn down.

Were this regime to persist and were the productivity of capital not to increase through time, causing the full employment line to collapse towards the origin, the trajectory would turn first eastwards and finally slightly towards the north as it approached the shed line, until labor were fully employed. This possibility is drawn in Fig. C-4, where the solid diagonal line is the full employment line for the initial year (1960), and where the dots represent successive yearly points along the trajectory of capital development. But the full employment line moves towards the origin each year too, occupying successively in 1965, 1970, and 1975 the positions indicated by the three dashed lines. So all points in the phase space beyond those linked together are unattainable because of an insufficiency of labor. In 1975, by which time K1 has increased to 1.21 and K2 fallen to 1.00, full employment has very nearly been achieved, and labor is about to constrain the solution; shortly after this occurs, the goal is struck and our objective function, equation (25), becomes obsolete.

To continue to full employment under the regime of maximum investment in the modern sector is a feasible but not the optimum policy. Eliminating unemployment in the minimum time involves switching at some point to the second regime, where the savings rate is still maximized but where as much new capital as possible is allocated to the traditional sector. In principle, the switch from the first to the second regimes could occur at any point along the trajectory from the very beginning (in 1960) to the very end (just after 1975); in the case of the Northeast it occurs in the 13th year, 1973 (see Fig. C-5). Having descended on the trajectory from the upper left of the abbreviated phase diagram in Fig. C-5, were the control EGKIC not to be switched from its maximum to its minimum value, the capital stock would continue to increase in the modern sector and fall in the traditional, as indicated by the points for 1974 and 1975 in the lower right. Switching EGKIC, however, propels the economy upwards along the trajectory to the left, with the result that it is K1 that

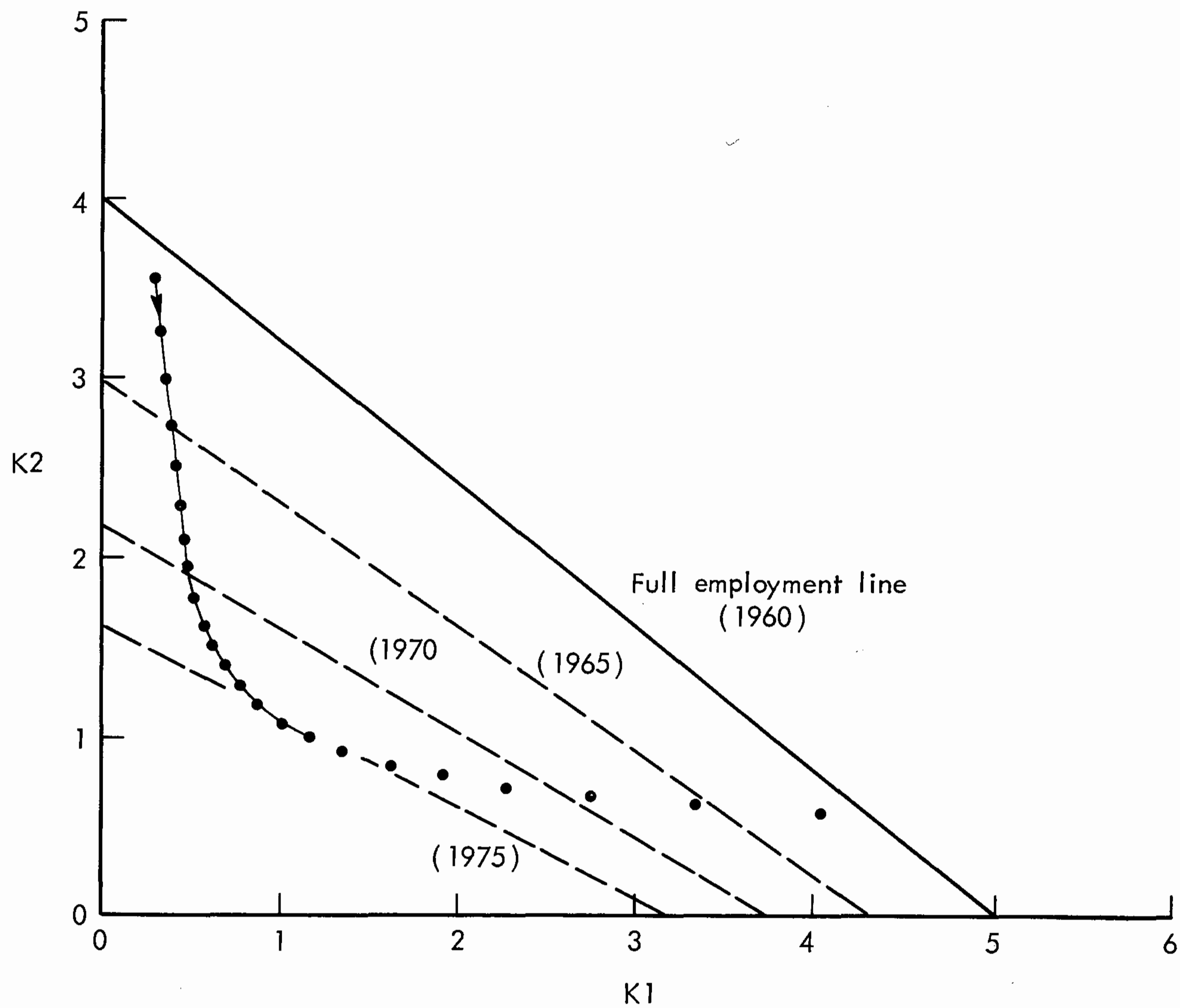


Fig. C-4—Trajectory for capital development in the Northeast, assuming maximum investment in the modern sector

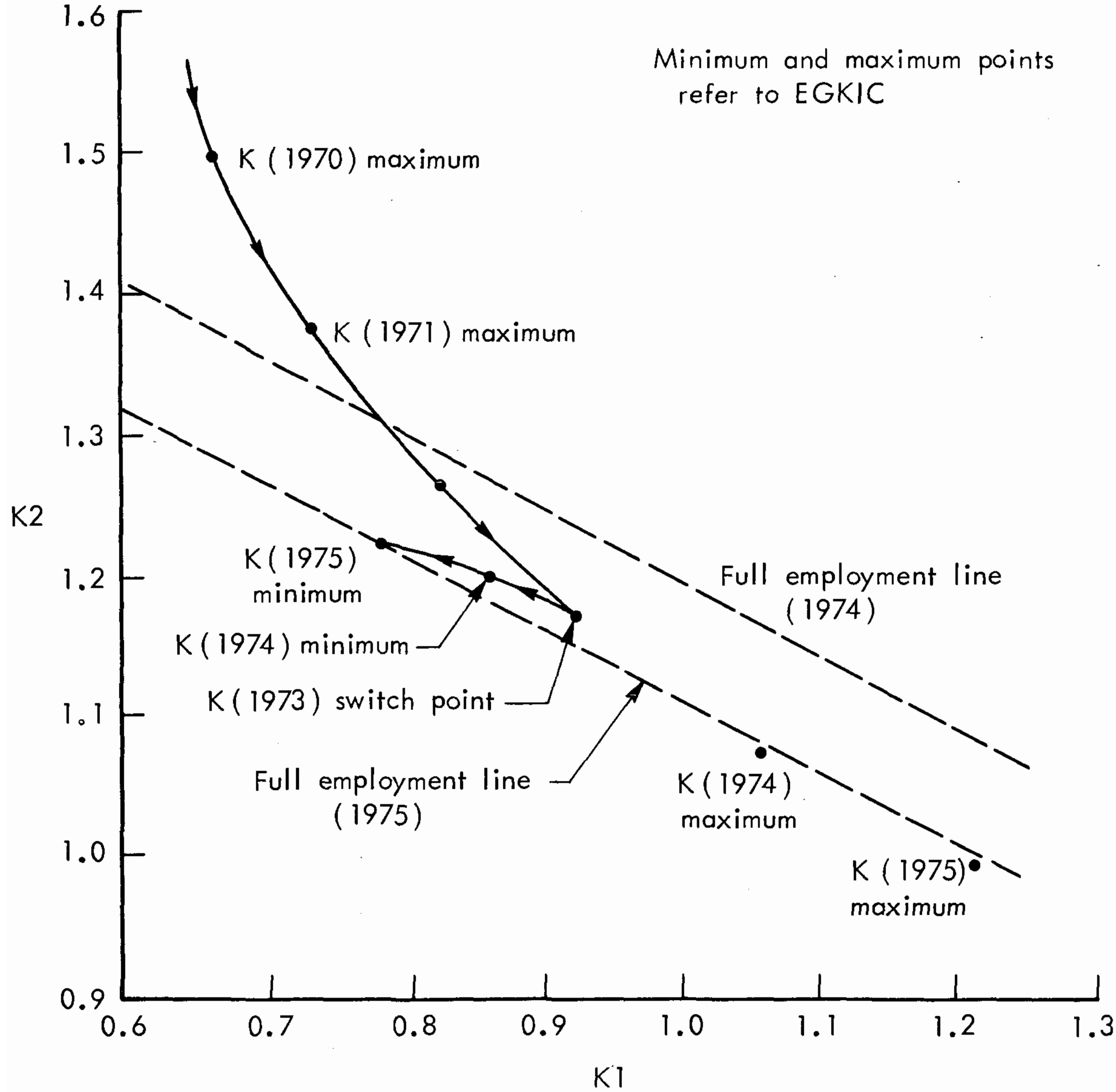


Fig. C-5—Trajectory for optimal capital development in the Northeast with the objective of full employment in the minimum time

falls, to 0.85 in 1974 and 0.79 in 1975, and K2 that rises, to 1.20 in 1974 and 1.225 in 1975.

According to the optimum policy, unemployment is eliminated as 1975 draws to a close. Switching from the one regime to the other has thereby achieved the goal of full employment a few months sooner.

The terminal composition of capital under the optimum policy is given by the coordinates of K (1975) EGKIC minimum (K1 = 0.79; K2 = 1.225) that under the feasible but non-optimal policy of maximum buildup of capital in the modern sector throughout by the coordinates of K (1975) EGKIC maximum (K1 = 1.21; K2 = 1.00). Compared with the optimum policy, by which full employment is most speedily attained, the alternative policy results in a capital stock, per capita, about 50 percent higher in the modern sector and 20 percent lower in the traditional sector. Given the higher productivity of capital in the modern sector, the difficulties, political and economic, of shifting, and the smallness of the temporal disadvantage, the alternative policy might well be preferred. The situation described above is unusual though, by chance, the slopes of the two trajectories (the one associated with EGKIC maximum and the other with EGKIC minimum) and the slope of the full employment line (see Fig. C-5) are nearly equal in 1973. <u>When</u> one switches, or even <u>whether or not</u> one switches, is thus of relatively little importance in terms of the interval necessary to eliminate unemployment. It is of considerable importance, though, on the relative sizes (K1:K2) of the capital stocks upon the attainment of full employment. If the trajectories and the full employment line were not parallel at the switch point, and there is no reason in theory why they should be, the optimum policy would show up to greater advantage.

COMPARISON WITH THE RESULTS OF THE SIMULATION MODEL

The differences between this optimal growth model and the simulation model of the body of the report (the former closed, with constant returns to scale, consumption limited by production, investment endogenous, and only two instruments optimally imposed; the latter open, with

varying returns to scale in the modern sector, consumption permitted to exceed output, investment exogenous, and several arbitrary instruments) are so great as to make impossible any close comparison. An examination of the time paths of the macroeconomic variables, total output (TØ), employment (PEI + PEA), and unemployment (PU) for the optimal growth model and the simulation model in its base case, described in Section IX, reveals similarities: underemployment first rises, both in percentage and absolute terms. reaching in the case of the analytic model a peak of 14 percent of the labor force in 1968 and in the case of the simulation model a peak of 9 percent in 1977, and then falls. Only for the analytic model is unemployment eliminated within a generation, this being achieved by persisting in investing a higher proportion of the output of the modern sector.

Let us compare the behavior of the growth model when its controls have been set so as to eliminate underemployment as quickly as possible with its behavior under non-optimal values of the controls. Such a comparison underlies Fig. C-6, in which the growth paths of total output, total employment, and consumption per capita are plotted for the optimal and near-optimal cases already described, and for a third case in which the savings rate is lower by two-fifths. In terms of our parameter values, the optimal values of the controls (that is, those that will eliminate unemployment as quickly as possible) are APIKC (the savings rate) = maximum = 0.5 throughout, and EGKIC (the fraction of investment assigned to the modern sectors) = maximum = 0.9 for the first 13 years, followed by EGKIC = minimum = 0.3 for the final 2 years. The near-optimal case is that in which EGKIC = maximum = 0.9 throughout. In the alternative case, APIKC = 0.3 and EGKIC is at its maximum.

As one might expect, a lower rate of savings yields a lower growth rate for the economy (see the top curves in Fig. C-6), so much so that by 1975 total output is a little less than half that of the near-optimal case and a little more than half that of the optimal case. A lower savings rate also increases the period over which unemployment persists; the growth path would have to be extended for another 15 years, till 1990, before the curve for total employment would rise up

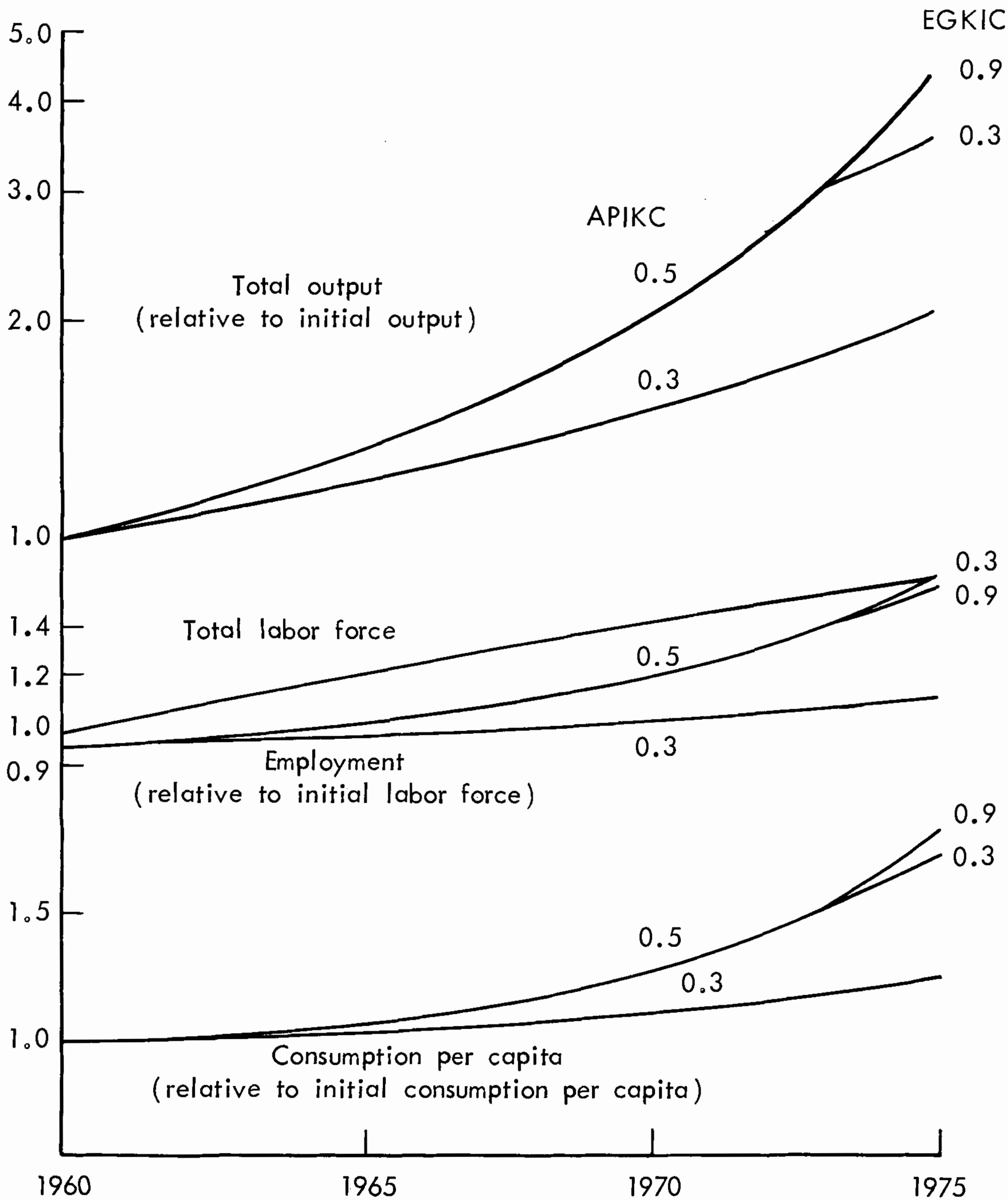


Fig. C-6—Growth paths of total output, total employment, and consumption per capita with optimal, near-optimal, and sub-optimal values of the controls

to meet the curve for the total labor force. Finally (see the bottom set of curves of Fig. C-6) a lower savings rate permits higher consumption per capita for the first 4 years but compels lower consumption per capita thereafter. These deductions are not unexpected in the light of the results of the simulation runs (in Sections X and XI) of the more complex model of the economy of the Northeast.

SOURCES

The items below are a partial listing of material on Thailand, particularly its Northeast, including both governmental and nongovernmental publications. The sources were the catalogs at RACIC and CINFAC, individuals at the U.S. Department of State and the U.S. Department of Defense, and citations in academic works. Where a relatively recent publication has a large bibliography, it rather than the items in the bibliography were cited; only when the material appeared to be novel was it extracted. Certain references were deleted from the final draft; these are indicated by numbers in parentheses.

Bibliographies

1. American Universities Field Staff, Inc., List of Publications of the A.U.F.S., January 1952 - December 1964, New York: A.U.F.S., Inc., 1965.

2. Amyot, Jacques, and Robert W. Klichert, "Directory of the Social Sciences in Thailand, 1963," Bangkok: Military Research and Development Center, 1963, 96 pp.

3. Bibliography of Material About Thailand in Western Languages, Bangkok: The Central Library of Chulalongkorn University, 1960, 325 pp.

4. Conley, M.C., and Joann L. Schrock, Preliminary Survey of Insurgency in Urban Areas, 3 vols. (& bibliography), Washington: Special Operations Research Office (SORO), February 1965.

5. Cowa Survey, (Current Work in Old World Archeology) Area 19 - Southeast Asia (summary of recent work and annotated bibliography).

6. Embree, John F., and Lillian O. Dotson, Bibliography of the Peoples and Cultures of Mainland Southeast Asia, New Haven: Yale University, Southeast Asia Studies, 1950, 821 pp.

7. Hay, Stephen N., and Margaret H. Chase, Southeast Asian History: A Bibliographic Guide, New York: Frederick A. Praeger, 1962.

(8.) Deleted from final draft.

9. Howard, R. C. et al., "Bibliography of Asian Studies," The Journal of Asian Studies, Vol. XXII, No. 5 (1962), pp. 1-258.

10. International Bibliography of Social and Cultural Anthropology, UNESCO (issued annually since 1957, books and articles listed by author and country in the index).

11. Journal of Asian Studies (formerly Far Eastern Quarterly) (annual publication).

12. La Font, Pierre Bernard, Bibliographie du Laos, Paris: École Francaise d-Extrème-Orient, 1964.

13. Lasker, Bruno, Books on Southeast Asia: A Select Bibliography, rev. ed. with supplements, New York: Institute of Pacific Relations, 1959.

(14.) Deleted from final draft.

15. Mason, John Brown, and H. Carroll Parish, Thailand Bibliography, University of Florida Libraries, Department of Reference and Bibliography, Bibliographic Series No. 4, Gainesville, 1958, 247 pp.

16. Monthly List of Periodical Articles on the Far East and South East Asia, London: Library of the School of Oriental and African Studies, University of London, 1954.

17. McKinstry, John, Bibliography of Laos and Ethnically Related Areas, Los Angeles: University of California at Los Angeles, Department of Anthropology, Laos Project Paper No. 22, 1962 (?).

18. Rakasasataya, Amara, and Prachak Sudhiyakorn, Bibliography on Social Sciences in Thailand, Bangkok: Institute of Public Administration, 1965.

19. Rakasasataya, Amara, Titaya Suvanajata, and Kaewichira, "Development of Social Sciences in Thailand," Bangkok: Institute of Public Administration, 1965.

20. "Rural Sociology in South-East Asia -- Trend Reports and Bibliographies," Current Sociology, Vol. VIII, No. 1, 1959.

21. Sharp, L. (dir.), et al., Bibliography of Thailand, Ithaca, N.Y.: D.F.E.S., 1956.

22. Stucki, Curtis W., American Doctoral Dissertations on Asia, 1933-1962, (Including Appendix of Masters' Theses at Cornell University), Ithaca: Cornell University, Southeast Asia Program, Department of Asian Studies Data Paper No. 50, December 1963.

23. The Asia Foundation, Library Notes, San Francisco: n.d.

24. Tropical Abstracts, Institute for the Tropics, Netherlands.

25. United Nations Economic Council for Asia and the Far East, Asian Bibliography, Bangkok (semiannual).

(26.) Deleted from final draft.

(27.) Deleted from final draft.

28. United States Joint Publications Research Service, Geographical Index of Thailand, Washington: Department of Commerce, November 29, 1965.

29. United States Library of Congress, Southern Asia Accessions List, monthly.

30. Yale University, Southeast Asia Studies Program, bibliographies, 1948-present; Translation Series, 1949-present; Cultural Report Series, 1950 - present.

General Material

31. Adams, Inez, "Rice Cultivation in Asia," American Anthropologist, Vol. 50, 1948, pp. 256-282.

32. American University, SORO Foreign Area Studies Division, U.S. Army Area Handbook for Thailand, June 1963.

(33.) Deleted from final draft.

34. Amyot, Jacques, Intensive Village Study Project, April-May 1964, Ban Nonlan, Amphur Uthumphonphisai, Sisaket, Preliminary Report, Bangkok: Department of Social Studies, Faculty of Political Science, Chulalongkorn University, December 20, 1964.

35. Andrews, James M., Siam: Second Rural Economic Survey, 1934-1935, Bangkok: Bangkok Times Press, 1935.

36. Anuman, Phya Rajadhon, Five Papers on Thai Custom, Cornell University, Southeast Asia Program, Data Paper No. 28, Ithaca: Cornell University, 1958.

37. -----, "Me Phosop or the Rice Mother," Journal of the Siam Society, 1955.

38. -----, "Phi" (Spirits), Journal of the Siam Society, Vol. 16, 1954.

39. -----, "The End of Buddhist Lent," Journal of the Siam Society, Vol. XLII, Part 2, January 1955.

40. -----, The Life of the Farmer in Thailand, New Haven: Yale University, Southeast Asia Studies, 1955.

41. Atlantic Report, "Thailand," Atlantic Monthly, December 1964, pp. 13 ff.

42. Atlas of South-East Asia, London: MacMillan & Co., Ltd., 1964.

43. Atthakor, Bunchana, "Conditions in the Thai Northeast," Far Eastern Economic Review, Vol. 35, March 15, 1962, pp. 597-599.

44. Ayal, E. B., "Economic Nationalism in Thailand," mimeographed, Harvard Center for International Studies, July 1965.

45. -----, "Public Policies in Thailand under the Constitutional Regime -- A Case Study of an Underdeveloped Country," unpublished Ph.D. thesis, Cornell University, September 1961.

46. -----, "Some Crucial Issues in Thailand's Economic Development," Pacific Affairs, Vol. XXXIV, No. 2 (Summer 1961), pp. 157-164.

47. -----, "Thailand's Six-Year National Economic Development Plan," Asian Survey, January 1, 1962.

48. Baker, Vernon W., and William R. Stanley, "A Special Review of the Tank Irrigation Program in Northeast Thailand," Bangkok: U.S. Operations Mission to Thailand, July 7, 1955.

49. Baldwin, Hanson W., "Build-up by Americans in Thailand...," New York Times, January 23, 1966, pp. 1, 3.

50. -----, "Thais Expanding Armed Strength," New York Times, February 14, 1966, pp. 1, 4.

(51.) Deleted from final draft.

52. Barton, Thomas Frank, "Rainfall and Rice in Thailand," Journal of Geography, Vol. 62, No. 9, December 1963, pp. 414-418.

53. Barton, Thomas F., and S. Senanarong, An Economic Geography of Thailand: An Outline Study in Thai, Dhonburi, Thailand: Wutisuksa School P.O., 1958.

54. Benedict, Ruth, Thai Culture and Behavior, Cornell University Southeast Asia Program, Data Paper No. 4, Ithaca: Cornell University, 1955.

55. Bernatzik, Hugo, and E. W. Bernatzik, The Spirits of the Yellow Leaves, London: Transatlantic Arts, Ltd., 1958.

56. Bertholet, C.J.L., and Bencha Diswat, Housing and Food Patterns in Eleven Villages in Northeast Thailand, Ubol: Thailand-UNESCO Fundamental Education Centre (TUFEC), 1963.

57. Blakeslee, D. J., L. W. Huff and R. W, Kichert, Village Security Pilot Study, Northeast Thailand, Bangkok: 3 vols., Military Research and Development Center, May 1965.

58. Blanchard, W., Thailand, Its People, Its Society, Its Culture, New Haven: Human Relations Area Files Press, 1957.

59. Blofeld, John E., People of the Sun: Encounters in Siam, London: Hutchinson and Co., 1960.

60. Blofeld, J., "Tribes of North Thailand" (Meo and Yao), Journal of the Siam Society, Vol. 43, 1955, pp. 1-19.

61. Breitenbach, Charles A., "Crop Development in Thailand," Bangkok: U.S. Operations Mission, September 1964.

62. Brown, Lester R., "Agricultural Diversification and Economic Development in Thailand: A Case Study," Foreign Agricultural Economic Report No. 8, Washington: U.S. Department of Agriculture, Regional Analysis Division, Economic Research Service.

63. Bundhit Kantabutra, The Economy and National Income of Thailand, Bangkok: Office of the National Economic Development Board, September 1959.

64. Bunnag, C., and V. Chraraks, Climates of Siam, Bangkok: Hydrographic Dept., 1947.

65. Burling, Robbins, Hill Farms and Padi Fields: Life in Mainland Southeast Asia, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1965.

66. Busch, N. F., Thailand, An Introduction to Modern Siam, Princeton: Van Nostrand, 1959.

67. Buss, Claude A., Southeast Asia and the World Today, New York: Anvil Books, 1958.

68. Cady, John Frank, The Roots of French Imperialism in Eastern Asia, Ithaca: Cornell University Press, 1954.

69. Chandruang, Kumut, My Boyhood in Siam, New York: 1950.

70. Chavalit, Ungvechien, Sompong Thanasophon, Momrajwong Chandramsirichoke Chandratat and Surasri Sittisuk, "Economic Survey of Changwad Petchaboon," Bangkok: U.S. Operations Mission, Program Office, July 1, 1959, mimeographed.

71. Chongkhadikij, Theh, "Thailand Prepares for Guerrilla War," The Bangkok Post, January 1963, and Bangkok: SEATO, VI (4)/63-65.

72. -----, "The Northeast Story," The Bangkok Post, 3 March - 27 May 1963, Bangkok: SEATO, VI (4)/62-66.

73. Chuchart, Chaiyong, An Economic Study of Rice Marketing in Thailand, Bangkok: 1960.

74. -----, Production and Marketing Problems Affecting the Expansion of Corn Growing in Thailand, Bangkok: 1962.

75. -----, The Growing Importance of Upland Crops in the Foreign Trade of Thailand, Bangkok: 1962.

76. Chuchart, Chaiyong, and Bimbandhia Vasuwat, "Standardization of Grading and Improvement of Quality of Jute, Kenaf, and Allied Fibers in Thailand," Bangkok: National Research Council, March 1965.

77. Chuchart, Chaiyong, Gordon R. Sitton, Arb Nakajud, Somnuk Wickitpongse, Arkhom Soothipan, Sopin Tongpan and Bisal Kingpejaratana, Production and Marketing Problems Affecting the Expansion of Kenaf and Jute in Thailand: A Report of the Preliminary Survey, Bangkok: Kasetsart Economic Report No. 7, Kasetsart University, Faculty of Economics and Cooperative Science, February 1962.

78. Chula-Chakrabongse, Lords of Life: The Paternal Monarchy of Bangkok, 1782-1932, London: Alvin Redman, 1960.

79. Clark, Dorothy K., The Inland Waterway Transport System of Thailand, Bangkok: Research Analysis Corp. Field Office, September 1964.

80. Coast, John, Some Aspects of Siamese Politics, New York: Institute of Pacific Relations, 1953.

81. Cole, J. B., "Bridge Inventory and Replacement Program for Primary Highway System," Bangkok: U.S. Operations Mission, Public Works and Engineering Division, September 9, 1963, 17 tables, mimeographed.

82. Collis, Maurice, Siamese White, London: Faber & Faber, 1936.

83. Committee for Economic Development, "Strategic Factors of Economic Growth: The Case of Thailand," preliminary report, March 1965, mimeographed.

84. Coughlin, R. J., Double Identity; the Chinese in Modern Thailand, Hong Kong: Hong Kong University Press, 1960.

85. Credner, W., Cultural and Geographical Observations Made in the Tali Region (of Yunnan), Siam Society, 1934.

86. -----, Siam, Das Land der Tai, eine Landeskunde auf Grund eigener Reisen und Forschungen, Stuttgart: Engelhorns, 1935.

87. Daniel, Mann, Johnson and Mendenhall, International, Ground Water Exploration of the Khorat Plateau, Bangkok: U.S. Operations Mission, July 1961.

88. Darling, Frank C., Thailand and the United States, Washington: Public Affairs Press, 1965.

89. De Young, J. E., Village Life in Modern Thailand, Berkeley: University of California Press, 1955.

90. Dhaninivat, H. H., A History of Buddhism in Siam, Bangkok: reprinted from the Encyclopedia of Buddhism of the Government of Ceylon.

91. Dobby, Ernest H. G., Southeast Asia, London: University of London Press, 1950.

92. Dodd, William C., Tai Race, Elder Brother of the Chinese, Cedar Rapids, Iowa: 1923.

93. Dodd, William C. and H. G. Deignan, Siam - Land of Free Men, Smithsonian Institution War Background Series, No. 8, Washington: Smithsonian Institution, 1943.

94. DuBois, Cora A., Social Forces in Southeast Asia (2nd Edition), Cambridge: Harvard University Press, 1959.

95. Elegant, Robert S., The Dragon's Seed, Peking and the Overseas Chinese, New York: Macmillan, 1959.

96. Embree, J. F., "Thailand - A Loosely Structured Social System," American Anthropologist, Vol. 52, 1950, pp. 101-193.

97. Emerson, Rupert, Representative Government in Southeast Asia, Cambridge: Institute of Pacific Relations, 1955.

98. Fifield, Russell H., The Diplomacy of Southeast Asia, 1945-1958, New York: Harper and Bros., 1958.

99. Fraser, Thomas M., Jr., Rusembilan - A Malay Fishing Village in Southern Thailand, Ithaca, Cornell University Press, 1960.

100. Giarratana, A. C., The Highway System of Thailand, Bangkok: Research Analysis Corporation, August 1964.

101. Ginsburg, Norton S. (ed.), The Pattern of Asia, Englewood Cliffs, N.J.: Prentice-Hall, 1958.

102. Goldsen, Rose K., and Max Ralis, "Factors Related to Acceptance of Innovations in Bang Chan, Thailand," Ithaca: Cornell University, Southeast Asia Program, Department of Asian Studies, July 1963.

103. Gourou, Pierre, The Tropical World (2nd edition), New York: Longmans, Green and Co., Inc., 1958.

104. Guskin, Alan E., and Tussanee Svokthance, "Changing Values of Thai College Students: A Research Report," Bangkok: Chulalongkorn University, Faculty of Education, 1964.

105. Graham, Henry M., Some Changes in Thai Family Life, Kasetsart University, Institute of Public Administration, 1960.

106. Hall, D.G.E., A History of Southeast Asia, London: St. Martin's Press, Inc., 1955.

107. -----, "Looking at Southeast Asian History," Journal of Asian Studies, Vol. XIX, No. 3, May 1960.

108. Halpern, Joel M., Aspects of Village Life and Culture Change in Laos, New York: Council on Economic and Cultural Affairs, Inc., 1958.

109. -----, "Economic Development and American Aid in Laos," Practical Anthropology, Vol. 6, No. 4, July-August 1959.

110. -----, The Role of the Chinese in Lao Society, Santa Monica: The RAND Corporation, P-2161, March 1961.

111. -----, "Trade Patterns in Northern Laos," Eastern Anthropologist, Vol. 12, No. 2, 1958.

112. Hanks, L. M. and J. R. Hanks, "Diphtheria Immunization in a Thai Community," in Health Culture and Community, Benjamin Paul (ed.), New York: Russell Sage Foundation, 1955, pp. 155-188.

113. Hanks, L. M., "Indifference to Modern Education in a Thai Farming Community," Human Organization, Vol. 17, No. 2, n.d.

114. Harmon, E. D., "Comments on Dr. Hans Platenius' Report," Bangkok: U.S. Operations Mission, March 22, 1964, mimeographed.

115. Harrison, Brian, South-East Asia: A Short History, New York: St. Martin's Press, 1954.

116. Hauch, Helen et al., Food Habits and Nutrient Intakes in a Siamese Rice Village; Studies in Bang Chan, 1952-54, Ithaca: Cornell University, Southeast Asia Program, Data Paper No. 29, 1958.

117. Haworth, Howard F., Exploration for Ground Water, Northeastern Thailand, Bangkok: U.S. Operations Mission, 1962.

118. Heine-Geldern, Rober, Conceptions of State and Kingship in Southeast Asia, Cornell University Southeast Asia Program, Data Paper No. 18, 1956.

119. Heymann, H., Jr. et al., Security and Assistance in Thailand: Supplement on the Thai "Rice Premium," Santa Monica: The RAND Corporation, RM-4744-AID/ISA (Supplement), December 1965.

120. Bennett, A., "Thailand: The Ambiguous Domino," Conflict Studies (Current Affairs Research Studies Centre, London), No. 1, December 1969.

121. Horrigan, Frederick James, Local Government and Administration in Thailand: A Study of Institutions and their Cultural Setting, Ann Arbor: University Microfilms, 1959.

122. Howard, Lee M., John W. McDowell, Richard F. Peters and B. A. Rao, "Report of an Assessment of the National Malaria Eradication Project of Thailand," Bangkok: U.S. Operations Mission, February 1964.

123. Huff, Lee W., Mobile Development Unit Follow-Up, Bangkok: Military Research and Development Center, Ministry of Defense, November 1964.

124. Huff, Lee W., Observations on Mobile Development Unit-2 Operations, Bangkok: Military Research and Development Center, Ministry of Defense, June 1963.

125. Hutchinson, E. W., Adventures in Siam in the Seventeenth Century, London: Royal Asiatic Society, 1940.

126. Ingram, James C., Economic Change in Thailand Since 1850, Stanford: Stanford University Press, 1955.

127. Insor, D., Thailand, New York: Praeger, 1963.

128. International Bank for Reconstruction and Development, "Current Economic Position and Prospects of Thailand," Vol. I, Report FE-50a, September 25, 1965.

129. -----, "Report...on a Proposed Loan to the Kingdom of Thailand for the Me Klong Irrigation Project," November 16, 1964.

130. International Cooperation Administration, Thailand: U.S. Economic Cooperation, 1951-1956, Washington: 1957.

131. International Monetary Fund, "Thailand, Staff Report and Recommendations - 1964 Consultations," January 18, 1965.

132. Jackson, E. A., Soil and Crop Research in Northeast Thailand, Bangkok: Applied Scientific Research Corporation, 1964.

133. Joint Thai-U.S. Task Force, Preliminary Assessment of Education and Human Resources in Thailand, Bangkok: U.S. Agency for International Development, 1963.

134. Judd, Laurence C., Chao Rai: Dry Rice Farmers in Northern Thailand, 1961.

135. Kahin, George M., ed., Governments and Politics of Southeast Asia, Ithaca: Cornell University, Southeast Asia Program, 1959.

136. Kaufman, H. K., Bangkhuad -- A Community Study of Thailand, Locust Valley, New York: J. J. Augustin, Inc., for the Association of Asian Studies, 1960.

137. Kerr, A. et al., Flora and Vegetation, Fauna, Bangkok: Daily Trade News P.O., for the Dept. of Intelligence, Ministry of Economic Affairs, 1953.

138. Keyes, Charles F., Status and Rank in Thai-Lao Village, Ithaca: Cornell University Press, November 1964.

139. -----, "Thailand, Laos and the Thai Northeastern Problem," Australia's Neighbours, 4th Series, No. 17, July-August 1964, Melbourne: 1964.

140. King, John Kerry, Southeast Asia in Perspective, New York: MacMillan, 1956.

141. Klausner, William J., Focus of Interest, 1956.

142. -----, Popular Buddhism in Northeast Thailand, Bangkok: U.S. Operations Mission, 1962.

143. -----, Report on the Village of Nong Khon Near Ubon, Thailand, Bangkok: U.S. Operations Mission to Thailand, 1956.

144. -----, Site of Field Work: Village of Nong Khon, 1956, Bangkok: U.S. Operations Mission, 1956.

145. -----, The Northeast Migration Problem, Bangkok: U.S. Operations Mission, 1960.

146. Krit Samapuddhi (comp.), The Forests of Thailand and Forestry Programs, Bangkok: The State Railways of Thailand P.O., 1955.

147. Kuhn, Isobel, Ascent to the Tribes: Pioneering in Northern Thailand, Chicago: Moody Press, 1956.

148. Kunstader, Peter, The Lua' (Lawa) of Northern Thailand: Aspects of Social Structure, Agriculture, and Religion, Princeton: Princeton University, Center of International Studies, Research Monograph No. 21, 1966.

149. La Bar, F. M. et al., Ethnic Groups of Mainland Southeast Asia, New Haven: Human Relations Areas Files Press, 1964.

150. LaMoreaux, P. E. et al., Reconnaissance of the Geology and Ground Water of the Korat Plateau, Thailand, U.S. Department of the Interior, Geological Survey Water-Supply Paper 1429, 1959.

151. Landon, Kenneth P., Siam in Transition, Chicago: University of Chicago Press, 1939.

152. -----, Southeast Asia, Crossroad of Religions, Chicago: University of Chicago Press, 1949.

153. -----, "Thai Nationalism," Far Eastern Quarterly, February 1953.

154. -----, The Chinese in Thailand, New York: Institute of Pacific Relations, 1941.

155. Lasher, Robert E., Report, Mobile Information Team I, First Trip to Remote Areas in Amphur That Phanom and Amphur Khemma-Raj, Jan. 22 to Feb. 4, 1962, Bangkok: U.S. Information Service, n.d.

156. -----, Report, Mobile Information Team I, Second Trip: March 15 to April 4 (1962), Area Visited: Villages in Amphurs Saeka and Bungkhan, Changwat Nongkhai, Bangkok; U.S. Information Service, n.d.

157. -----, Report, Mobile Information Team I, Third Trip: May 21 to June 4 (1962) (First Mobile Team Follow-up Trip), Area Visited: Villages in Amphurs Khemma-Raj and That Phanom, Changwads Ubol and Nakorn Phanom, and Report, Mobile Information Team, Seventh Field Trip in 1962: December 12-22; Areas Visited: Villages in Amphurs Sangkha and Prasad, Changwad Surin, Bangkok: U.S. Information Service, n.d.

158. -----, Report, The Eighth Mobile Information Team Field Trip, a Follow-up Trip to Nongkhai Province; 32 Villages Visited in the Remote Areas of Bungkan, Saeka, Phon Phisai and Sri Chiengmai Districts, January 15 - February 4, 1963, Bangkok: U.S. Information Service, n.d.

159. -----, The Nineteenth Mobile Information Team Trip, Visits to 16 Villages in Nongkhai Province by the Nongkhai Provincial Mobile Information Team, September 14 - October 1, 1964, Bangkok: U.S. Information Service, n.d.

160. Lasker, Bruno, Peoples of Southeast Asia, New York: Alfred A. Knopf, 1944.

161. Le May, Reginald S., The Culture of Southeast Asia, The Heritage of India, London: George Allen and Unwin, Ltd., 1954.

162. Levy, J. E., "Economic Aspects of Thailand's Ability to Withstand Communism," unpublished thesis No. 1257, Maxwell AFB, Alabama: Air War College, April 1963.

163. Lingat, R., "Evolution of the Conception of Law in Burma and Siam, Journal of the Siam Society, Vol. 38, Part 1, 1950.

164. Long, Jancis F., Millard F. Long, Kamphol Adulavadhaya, and Sawart Pongsuwan, Economic and Social Conditions Among Farmers in Changwad Khonkaen, Bangkok: Faculty of Economics and Cooperative Science, Kasetsart University, September 1963.

165. Long, Millard F., "Economic Aspects of USOM's Program in Northeast Thailand," Bangkok: U.S. Operations Mission, 1 September 1964.

166. Long, Millard et al., "Economic Conditions among Farmers in Changwad Khonkaen," Bangkok: Kasetsart University, September 1963.

167. Loti, Pierre, Siam, translated from the French by W. P. Baines, New York: Frederick A. Stokes, 1930.

168. Madge, Charles, Survey Before Development in Thai Villages, New York: United Nations Series on Community Organization and Development, ST/SOA/SER. 0/25; ST/TAA.SER. D.25, 11 March 1957.

169. -----, Village Communities in North-East Thailand; Report on a Preliminary Survey for the Thailand-UNESCO Fundamental Education Centre (TUFEC), Bangkok: 1954.

170. -----, "Village Communities in Northeast Thailand: Survey of the Thailand-UNESCO Fundamental Education Center," UN Technical Assistance Program Report No. TAA/THA/I, New York: March 16, 1955.

171. Mahamakut University Students, Report on Socio-Economic Conditions of the People in Northeast Thailand, Bangkok: Wat Borvornivet.

172. Mahaphol, S., Teak in Thailand, Bangkok: The State Railway of Thailand P.O., 1955.

173. Majumdar, Ramesa-Chandra, Ancient Indian Colonies in the Far East, Vol. I, Lahore, India: 1927.

174. -----, Ancient Indian Colonization in Southeast Asia, Baroda, India: 1955.

175. Maspero, G., The Kingdom of Champa, Translation Series, No. 2, Southeast Asia Studies Program, New Haven: Yale University, 1949.

176. Matthew, Eunice, The Land and People of Thailand, Philadelphia: J. B. Lippincott, 1964.

177. Miller, Haynes, "A Bulwark Built on Sand (Laos)," The Reporter, November 13, 1958.

178. Mission of the International Bank for Reconstruction and Development, A Public Development Program for Thailand, Baltimore: 1960.

179. Moerman, Michael, "A Minority and Its Government: The Thai-Lue of Northern Thailand," Los Angeles: University of California, n.d. (1965?).

180. Moffat, Abbot Low, Mongkut, The King of Siam, New York: Cornell University Press, 1961.

181. Moormann, F. R., Sarot Monraken, and Samarn Panichapong, "Soils of Northeastern Thailand: A Key to Their Identification and Survey," Bangkok: Ministry of National Development, Land Development Department, Soil Survey Division, 1964.

182. Mousny, André, The Economy of Thailand: An Appraisal of a Liberal Exchange Policy, Bangkok, Social Science Assoc. Press of Thailand, 1964.

183. Movius, Hallam L., Jr., The Lower Paleolithic Cultures of Southern and Eastern Asia, Transactions of the American Philosophical Society, Vol. 38, Part 4, 1948.

184. Murchie, Gordon W., Report and Analysis of Communications Team II Assigned to Visit Remote Villages in Amphurs Chieng Kan, Tarlee and Dansai of Changwad Loey, March 15 to April 3, 1962, Udorn: U.S. Information Service, n.d.

185. -----, Report and Analysis of Communications Team II Assigned to Visit Remote Villages in Districts Wanon Niwat, Sawang Daen Din and Muang in Changwad Sakolnakorn, August 12, 1962 to September 4, 1962, Udorn: U.S. Information Service, n.d.

186. -----, Report and Analysis of Mobile Information Team II's First Follow-up Trip to Remote Villages in Districts Chieng Khan, Tar Lee and Dan Sai of Changwad Loey, February 9 to 24, 1963, Udorn: U.S. Information Service, n.d.

187. Murphy, C.J.V., "Thailand's Fight to the Finish," Fortune, October 1965, pp. 122 ff.

188. McFarland, Bertha Blount, McFarland of Siam: The Life of George Bradley McFarland, M.D., D.D.S., (afterwards Phra Ach Vidyagama), George E. McCracken, ed., New York: Vantage Press, Inc., 1958.

189. Nims, Cyrus R., City Planning in Thailand, Bangkok: Ministry of the Interior, City Planning Office, 1963.

190. Nuttonson, M. Y., The Physical Environment and Agriculture of Thailand, Washington: American Institute of Geography, 1963.

191. Palmer, Leslie H., "Changing Outposts, Western Communities in Southeast Asia," Yale Review, Vol. 47, 1957, pp. 405-415.

192. Patay, Philippe, A Study of Agricultural Development in North East Thailand, Ubol: Thai-SEATO Community Regional Technical Assistance Centre, June 1963.

193. Pelzer, Karl J., Pioneer Settlement in the Asiatic Tropics, New York: American Geographical Society, 1945.

194. Pendleton, R. L., "Land Use in Northeastern Thailand," Geographic Review, Vol. 33, January 1943.

195. -----, Soils and Land Use in Peninsular Siam, Tech. Bull. No. 3, Bangkok: Department of Agriculture, 1950.

196. -----, Thailand Aspects of Landscape and Life, New York: Duell, Sloan and Pearce, 1962.

197. Philipps, Herbert P., and D. A. Wilson, Certain Effects of Culture and Social Organization on Internal Security in Thailand, Santa Monica: The RAND Corporation, RM-3786-ARPA (Abr.), June 1964.

198. Phillips, H. P., Thai Peasant Personality, Berkeley: University of California Press, 1965.

199. Pickerell, Albert G., "The Press of Thailand, Conditions and Trends," Journalism Quarterly, Vol. 37, No. 1, Winter 1960.

200. Platenius, Hans, Northeast of Thailand: Its Problems and Potentialities, Bangkok: National Economic Development Board, 1963.

201. Platenius, Hans, and Vanee Lertdumkan, "The Rice Balance," mimeographed, Bangkok: National Economic Development Board, December 1963.

202. -----, "Notes on the System of Taxing Agricultural Production," mimeographed, Bangkok: National Economic Development Board, April 1, 1964.

203. Prenksasri, Vanas, "A Survey of Living Conditions of People in Certain Areas of the Northeast Region," The Natural and Social Science Magazine, Bangkok: 1963.

204. "Présence du Bouddhisme," France-Asie, February-June, 1959.

205. Purcell, Victor, The Chinese in Southeast Asia, New York: Oxford University Press, 1951.

206. -----, The Revolution in Southeast Asia, London: Thames and Hudson, 1962.

207. Wales, Horace Geoffrey Quaritch, Ancient Siamese Government and Administration, London: Quaritch, 1934.

208. -----, Ancient South-East Asian Warfare, London: Quaritch, 1952.

209. -----, Prehistory and Religion in Southeast Asia, London: Quaritch, 1957.

210. -----, Siamese State Ceremonies: Their History and Function, London: Quaritch, 1931.

211. -----, The Mountain of God, London: Quaritch, 1953.

212. Anuman, Rajathon, Life and Ritual in Old Siam: Three Studies of Thai Life and Customs, Don Mills, Canada, Burns and MacEachern, Ltd., 1961.

213. Raksasataya, Amara, and Titaya Suvanajata, Report on Community Headman Study, Bangkok: Institute of Public Administration, 1965.

214. Reeve, W. D., Public Administration in Siam, Royal Institute of International Affairs, 1951.

215. "Resources of the Tropics III - Southeast Asia," Focus, Vol. IV, No. 6, February 1954.

216. Riggs, Fred W., "The Model for the Study of Thai Society," Bangkok: Institute of Public Administration, 1964.

217. Rose, S., "Constitutions in South-East Asia," St. Antony's Papers (Oxford), No. 7, 1960.

218. Rula, A. A., W. E. Grabau, A. C. Orvedal, H. W. Harden, G. W. Ansted, and T. F. Czako, Environmental Factors Affecting Ground Mobility in Thailand; Preliminary Survey, Vicksburg; May 1963.

219. Ruttan, Vernon W., A. Soothipan, and E. C. Verregas, "Changes in Rice Production and Yield in the Philippines and Thailand," mimeographed, 1965.

220. Samapudhi, Krit, The Forests of Thailand and Forestry Programs, Bangkok: Royal Forestry Department, Ministry of Agriculture, 1957.

221. -----, Yarng Oil, Bangkok: Royal Forestry Department, Ministry of Agriculture, 1954.

222. Sawaeng, Kulthongkham, and Shao-er Ong, Rice Economy of Thailand, Bangkok: Ministry of Agriculture, Division of Agricultural Economics, 1964.

223. Schaaf, C. Hart, and R. H. Fifeld, The Lower Mekong: Challenge to Cooperation in Southeast Asia, Princeton: D. Van Nostrand, Inc., 1963.

224. Scoville, O. J., and Alfred Thieme, Jr., Agricultural Development in Thailand, Bangkok: U.S. Operations Mission, June 1964.

225. Seidenfaden, Erik, "The So and the Phuthai," Journal of the Siam Society, Vol. 34, Part 2.

226. -----, The Thai Peoples, Book 1, The Origins and Habitats of the Thai Peoples with a Sketch of Their Material and Spiritual Culture, Bangkok: The Siam Society, 1963 (with bibl.).

227. Shaplen, Robert, "A Reporter at Large: Both Banks of the Mekong," The New Yorker, January 16, 1965, pp. 78 ff.

228. Sharp, Lauriston, "Peasants and Politics in Thailand," Far Eastern Survey, Vol. XIX, No. 15, 1950.

229. -----, Siamese Rice Village: A Preliminary Study of Bang Chan, 1948-1949, Cornell Research Center, Cornell University Southeast Asia Program, June 1953.

230. "Siam," Encyclopaedia Britannica, Vol. 20, 1960, pp. 589-597.

231. Siemer, Deanne C., "Marketing in Rural Thailand," M.A. Thesis in Asian Studies, University of Hawaii, June 1964.

232. Sitton, Gordon, "The Role of the Farmer in the Economic Development of Thailand," OECA paper, September 1962.

233. -----, "The Role of Farm Management in the Economic Development of Thailand," Paper presented to the Agricultural Society of Thailand, May 30, 1961.

234. Sitton, Gordon R., Chaiyong Xuxati, and Phimpan Siriwong Na-Ayudhaya, "The Growing Importance of Upland Crops in the Foreign Trade of Thailand," The Natural and Social Science Magazine, Bangkok: 1963.

235. Skinner, G. W., Chinese Society in Thailand: An Analytical History, Ithaca: Cornell University Press, 1957.

236. -----, Leadership and Power in the Chinese Community of Thailand, Ithaca: Cornell University Press, 1958.

237. Smitinand, Tem, Natural Vegetation and Land Cover of Northeast Thailand, Bangkok: n.d.

238. Spencer, Joseph E., Asia, East by South: A Cultural Geography, New York: John Wiley and Sons, 1954.

239. Srisavasdi, Boon Chuey, The Hill Tribes of Siam, Bangkok: Khun Aroon, 1963.

(240.) Deleted from final draft.

241. Suriyabongs, L., The Buddha's Doctrine of Truth and Buddhist Religion as Practiced in Siam, Bangkok: 1936.

242. Sutton, J. L., ed., Problems of Politics and Administration in Thailand, Bloomington: Indiana University, Department of Government, Institute of Training for Public Service, 1962.

243. Suvarnasuddhi, Khid, Some Commercial Timbers of Thailand, Their Properties and Uses, Bangkok: Royal Forestry Department, Ministry of Agriculture, 1950.

244. Textor, Robert B., "From Peasant to Pedicab Driver: A Social Study of North-eastern Thai Farmers who periodically migrated to Bangkok and became Pedicab Drivers," New Haven: Yale University Press, 1961.

245. -----, "The Northeast Samlor Driver in Bangkok," in The Social Implications of Industrialization and Urbanization - Five Studies in Asia, Calcutta: UNESCO, 1956.

246. Thailand Culture Series - a series of pamphlets on literature, architecture, festivals, music, sculpture, drama, marriage and language by outstanding Thai scholars, Bangkok: National Culture Institute.

247. Thailand, Government of, Department of Highways, Proposed Program for Development of Highways in Thailand, Bangkok: June 1962.

248. -----, Department of Mines, Report on Ground Water Exploration and Development of the Khorat Plateau Region, Bangkok: Ministry of Interior, Ground Water Bulletin No. 1, 1959.

249. -----, Ministry of Agriculture, Crop Distribution by Changwada, Bangkok: USOM, TAAVS, 1959.

250. -----, -----, Foreign Agricultural Relations Division, Agriculture in Thailand, Bangkok: Prayat Jalaputra at Udom Press, 1957.

251. -----, -----, Agriculture in Thailand, 1961, Bangkok, 1962 (?).

252. -----, -----, Thailand and Her Agricultural Problems (rev. ed.), Bangkok: 1950.

253. -----, -----, Thailand, Economic Farm Survey, 1953, Bangkok: 1954 (?).

254. -----, Ministry of Commerce, The Department of Commercial Intelligence, Thailand, Nature and Industry: Physical Features, Geology, Climate, Bangkok: The State Railways of Thailand P.O., 1951.

255. -----, Ministry of Commerce and Communications, The Teak Industry of Siam, D.R.S. Bourke-Borrowes, Bangkok: Bangkok Times Press, 1927.

256. -----, Ministry of Communications, Royal State Railways of Siam, Fiftieth Anniversary, 1897-1947, Bangkok: Royal State Railways P.O., 1947.

257. -----, Ministry of the Interior, Department of Public Welfare, Report on the Socio-Economic Survey of the Hill Tribes in Northern Thailand, Bangkok: September 1962.

258. -----, National FAO Committee, Thailand and Her Agricultural Problems, Bangkok: Ministry of Agriculture, 1949.

259. -----, Public Relations Department, Aspects and Facets of Thailand, Bangkok: 1958.

260. -----, "The Government of Thailand's Reply to the United Nations' Questionnaire on Economic Trends, Problems, and Policies, 1963-1964," mimeographed, 1964.

261. -----, Royal Thai Army, "Special Operations Center" (description of the program), Bangkok: n.d.

262. "The Nations of Southeast Asia," Current History, February 1960.

263. Thieme, A., Data on Economic and Social Welfare Conditions in Northeast Thailand and the Bangkok-Thonburi Area, Bangkok: USOM Airgram, 26 June 1964.

264. Thirawat, Sukhum, "The Northeast Region of Thailand," The Bangkok Post, November 19 through December 3, 1955.

265. Thomas, William L., Jr., Land, Man and Culture in Mainland Southeast Asia, New York: Wenner-Gren Foundation for Anthropological Research, 1957.

266. Thompson, Virginia M., Thailand, the New Siam, New York: MacMillan, 1941.

267. Topping, Seymour, "Next on Peking's Hit Parade," The New York Times Magazine, February 20, 1966, pp. 30 ff.

268. Transportation Consultants, Inc., A Comprehensive Evaluation of Thailand's Transportation System Requirements, Washington: June 1959.

269. Udompong, Phorn, Amphorn Vijitphan, Denpong Pollakorn, and Suvit Jongcharoen, "Rural Migration," The Natural and Social Science Magazine, Bangkok: 1963.

270. United Nations, Committee for the Coordination of Investigations of the Lower Mekong Basin, Annual Report 1964, Report E/CN.11/WRD/MKG/L.129, Saigon: January 11, 1965.

271. -----, ECAFE, Economic Survey of Asia and the Far East, 1965, New York: 1964.

272. -----, -----, Agricultural Development of Thailand, Bangkok: 1955.

273. -----, Food and Agriculture Organization, Report of the FAO Fisheries Mission for Thailand, Washington, 1949.

274. United States Agency for International Development, Country Assistance Program, FY 1967, Thailand, Part II, Washington: October 1965.

275. United States Army, Area Handbook for Thailand, Washington: 1963.

(276.) Deleted from final draft.

(277.) Deleted from final draft.

278. United States Department of Agriculture, An Economic Analysis of Far Eastern Agriculture, Foreign Agricultural Economic Report Number 2, Washington: November 1961.

(279.) Deleted from final draft.

280. United States Department of the Interior, Geologic Reconnaissance of the Mineral Deposits of Thailand, Washington: U.S. Government Printing Office, 1951.

281. -----, Survey of Water Resources of the Mun and Chi River Basins, Washington: March 1965.

(282.) Deleted from final draft.

283. United States Information Service, The Sixteenth Mobile Information Team Field Trip Visits to 11 Villages in Nakorn Phanom Province, Bangkok: 1964.

284. -----, The Seventeenth Mobile Information Team Trip, April 19 through May 2, 1964, Bangkok: 1964.

285. U.S. Operations Mission, Training Division, "A Report on Participant Follow-up and Evaluation," Bangkok: May 1965.

(286.) Deleted from final draft.

287. U.S. Operations Mission, Thailand, Observer's Report on Trip with Mobile Development Team No. 2, Amphur Kamchaee, Changwad Nakorn Panom, May 25 to June 3, 1963, 13 pp.

288. U.S. Operations Mission, Public Administration Division, Organizational Directory of the Government of Thailand, Bangkok: 1964.

289. Vadakarn, L. V., Thailand's Case, Bangkok: The Thai Commercial Press, 1941.

290. Vandenbosch, Amry, and Richard A. Butwell, Southeast Asia Among the World Powers, Lexington: 1958.

291. Vella, Walter F., Siam Under Rama III, 1824-1851, Association for Asian Studies Monograph 4, 1957, Locust Valley: J. J. Augustin, Inc., 1957.

292. -----, The Impact of the West on Government in Thailand, University of California Publications in Political Science, Vol. 4, No. 3, Berkeley: 1955.

293. Viravong, Maha Sila, History of Laos, New York: Paragon Book Reprint Corp., 1964.

294. Wagner, Melvin, Agricultural Development Research: Some Priorities and Methods, Bangkok: Kasetsart University, 1964.

295. Wallace, Maude E., Phillip V. Cardon, and James E. Crosby, Jr., "Report of the USOM Consultant Team on Research and Extension for the Government of Thailand and the United States Operation Mission to Thailand," Bangkok: U.S. Operations Mission, June 1959.

296. Warner, Denis, "Aggression by Seepage in Northeast Thailand," The Reporter, October 25, 1962, pp. 33 ff.

297. Waterways Experiment Station, Environmental Factors Affecting Ground Mobility in Thailand, Preliminary Survey, Technical Report and Appendices A-H, May 1963, 9 vols.

298. Wiens, Herold J., China's March Toward the Tropics (Yale University, Foreign Area Study), Hamden, Conn.: Shoe String Press, 1954.

299. Wening, Rudolf, Thailand, New York: Universe Books, 1961.

300. Wells, K. E., Thai Buddhism: Its Rites and Activities, published Ph.D. thesis, Faculty of Philosophy, Columbia University, Bangkok: Bangkok Times Press, February 1939.

301. White, Gilbert F., "The Mekong River Plan," Scientific American, Vol. 208, No. 4, April 1963, pp. 49-59.

302. Wilson, David A., Politics in Thailand, Ithaca: Cornell University Press, 1962.

303. Wittfogel, Karl A., Oriental Despotism: A Comparative Study of Total Power, New Haven: Yale University Press, 1957.

304. Wood, W.A.R., A History of Siam, London: 1926.

305. Yale University, Ethnic Groups of Northern Southeast Asia, Series 1, No. 30, 1950 (Thailand).

306. Yatsushiro, Toshio, The Appeal of Communism in Northeast Thailand, Bangkok: U.S. Operations Mission, December 1963.

307. -----, The Village Organizer in Thailand: A Study of His Needs and Problems, Bangkok: Ministry of the Interior, Department of Community Development and United States Operations Mission to Thailand, December 1964.

308. Young, Ernest, Kingdom of the Yellow Robe, Westminster: 1907.

309. Young, Oliver Gordon, The Hill Tribes of Northern Thailand; The Origins and Habitats of the Hill Tribes together with Significant Changes in their Social, Cultural & Economic Patterns, USOM Monograph No. 1, Bangkok: Government of Thailand and U.S. Operations Mission to Thailand, May 1961.

310. Zimmerman, Carle C., Siam, Rural Economic Survey, 1930-31, Bangkok: Bangkok Times Press, 1931.

311. Klausner, William J., Progress Report to the Ford Foundation, 3 Parts, mimeographed, 1956.

Statistical and Periodical Sources

312. Bangkok Bank Limited, Bangkok Bank Monthly Review, Bangkok.

313. -----, 1963 Annual Report, Bangkok: March 1, 1964.

314. -----, Thailand's Economy: A Statistical Portrait, Bangkok.

315. Bank of Thailand, Annual Economic Reports.

316. Ministry of National Development, Department of Technical and Economic Cooperation, Facts and Figures on the Economy of Thailand, Bangkok: September 1964.

317. Thailand, Government of, Office of the Prime Minister, Bureau of the Budget, Budget in Brief, FY 1965, Bangkok: September 1964.

318. -----, Department of Rice, "Annual Reports on Rice Production," Bangkok.

319. -----, Ministry of Agriculture, Department of Fisheries, A General Account on the Fisheries of Thailand, Bangkok: Nujomkij Press, 1956.

320. -----, -----, Division of Agricultural Economics, Agricultural Statistics of Thailand, 1954, Bangkok: University of Thammasat Printing Press, 1956.

321. -----, -----, -----, Agricultural Statistics of Thailand, 1963, Bangkok: 1965.

322. -----, Ministry of the Interior, Kansamruet, Sammano Khrua Thua Ratchannachak Thai, P.S. 2490 (Population Census of Thailand, 1947).

323. -----, National Economic Council, Central Statistical Office, Statistical Year Book of Thailand, No. 22, Vol. 1, B.E. 2488 (1945) to 2498 (1955), Bangkok: Royal State Railways P.O., 1958.

324. -----, Economic Development Board, Monthly Bulletin of Statistics, Bangkok: Thai Central Statistical Office, monthly.

325. -----, -----, National Income, 1962, Bangkok: National Income Office, National Income Division, 1962.

326. -----, -----, Central Statistical Office, Thailand Population Census, 1960, Changwad Series, 71 vols., Bangkok: Nai Arthorn Bannaprudit.

327. -----, -----, The National Economic Development Plan 1961-1966; Second Phase: 1964-1966, Bangkok: January 1964.

328. -----, -----, The Northeast Development Plan, 1962-1966, Bangkok: 1963 (?).

329. -----, National Statistical Office, Census of Agriculture, 1963, 71 vols. (Changwad Series) plus 1 (Summary), Bangkok: 1965.

330. -----, -----, Household Expenditure Survey BE2505: Northeast Region, Advance Report, Bangkok: 1963 (?).

331. -----, -----, Quarterly Bulletin of Statistics, Bangkok: quarterly.

332. -----, Thailand: Official Yearbook, 1964, Bangkok: Government House Printing Office, 1965.

333. -----, Royal Thai Navy, Meteorological Department, Monthly and Annual Rainfall of Thailand for 1953, Bangkok: Royal State Railways, P.O., 1955.

334. U.S. Department of Commerce, Thailand - A Market for U.S. Products, World Trade Information Service, Supplement No. 3 to Part 1, Washington: April 1962.

335. -----, World Trade Information Service, Basic Data on the Economy of Thailand, Washington: Part I, No. 56-82, 1956; Part I, No. 60-67, 1960.

336. U.S. Operations Mission, National Statistical Office, Changwat-Amphur Statistical Directory, Bangkok: USOM-NSO, Department of Local Administration, November 1965.

337. Usher, D., "The Thai National Income at United Kingdom Prices," Bulletin of the Oxford University Institute of Economics and Statistics, Vol. 25, 1963, pp. 199-214.

(338.) Deleted from final draft.

339. Asia; Asian Quarterly of Culture and Synthesis, Saigon, Vietnam.

340. Asian Perspectives, 1957 - present, a journal issued by the American Branch of The Far Eastern Prehistory Association.

341. Asian Review (formerly the Asiatic Review, 1905-1952), London: 1953 - present.

342. Asiatic Society of Bengal, Calcutta: 1832 - present.

343. Bulletin de l'Ecole Francaise d'Extreme-Orient, Hanoi and Paris: 1901 - present.

344. Cornell University, Southeast Asia Program, Department of Far Eastern Studies, data papers.

345. Eastern Anthropologist, Lucknow, India: 1947 - present.

346. Far Eastern Economic Review, Hong Kong: 1945 - present.

347. Far Eastern Survey, New York: 1932 - present.

348. Journal of the Burma Research Society: 1911-1941, 1948 - present.

349. Journal of the Royal Asiatic Society, Malayan Branch, Singapore: 1923 - present (formerly the Journal of the Royal Asiatic Society, Straits Branch).

350. Journal of the Siam Society, Bangkok: 1904 - present.

351. Journal of the Thailand Research Society, London and Bangkok: 1904 - . Anl.

352. Journal of the West China Border Research Society, Chengtu: 1922 - 1945.

353. Pacific Affairs, New York: 1926 - present.

354. United Asia, Bombay: 1948 - present.

355. United Nations Economic Bulletin for Asia and the Far East, New York.

Entertainments

356. Collis, Maurice, The Grand Peregrination; Being the Life and Adventures of Fernao Mendes Pinto, London: Faber and Faber, Ltd., 1949.

357. Crooks, Florence B., Tales of Thailand, 1942.

358. Dooley, Thomas A., "Foreign Aid -- The Human Touch," New York Times Magazine, April 20, 1958.

359. d'Orleans, Prince Henri, Around Tonkin and Siam, London: 1894.

360. Flessen, Katherine N., Laos Folk-Lore of Father India, New York, 1899.

361. Greene, Graham, Quiet American, New York: Viking Paperback, 1962.

362. Grondahl, Kathryn, The Mango Season, New York: William Morrow and Co., Inc., 1954.

363. Keusen, Hans, and Michael Edwardes, South Asia, London: Frederick A. Praeger, 1958.

364. Landon, Margaret, Anna and the King of Siam, New York, John Day Co., 1944.

365. Lederer, W. J., and E. L. Burdick, The Ugly American, New York: Norton, 1958.

366. Le May, Reginald S., Asian Arcady: The Land and People of Northern Siam, Cambridge: 1926.

367. Manunet Banhan, Phya, Siamese Tales, Old and New, Translated by Reginald Le May, London: Noel Douglas, 1930.

368. Maugham, W. Somerset, The Gentlemen in the Parlor, London: Heinemann, Ltd., 1930.

369. Rama Rau, Santha (Mrs. Faubion Bowers), View to the Southeast, New York: Harper and Brothers, 1957.

370. Sibunruang, J. K., Khun Chang, Khun Phén, Paris: Annales Musee Guimet, 1960.

371. Zimmer, Heinrich Robert, The Art of Indian Asia, Bollingen Series, No. 39, New York: Pantheon Books, 1955.

General Material, concluded

372. Government of Thailand, Office of the Prime Minister, National Statistical Office, private communication.

373. Wold, H. and Jureén, L., Demand Analysis, New York: John Wiley and Sons, 1953.

374. Discussion with Mr. Thavone Na Champassak, Agricultural Officer, Phone Thong district, Champassak province, Laos.

375. Crocco Ferari, Juan, Ensayos Sobre La Poblacion Chilena, Santiago: 1947.

376. Moerman, Michael, "Farming in Ban Phaed: Technological Decisions and their Consequences for the External Relations of a Thai-Lue Village," unpublished Ph.D. Thesis, Yale University, New Haven: 1964.

377. Seminar in Santa Monica, California, August 30, 1966, attended by gamnans (tambol chiefs) from the northeast of Thailand, Messrs. Pauk Punham, Kampon Umpon, Sutta Kahna, Phut Yotha, and Jom Opprom.

378. Muscat, R. J., Development Strategy in Thailand - A Study of Economic Growth, New York: Praeger, 1966.

379. Silcock, T. H., "Thai Money: Review Article," Malayan Economic Review, Vol. XI, No. 1 (April 1966).

380. Muscat, R. J., "Growth and the Free Market: A Case Study in Thailand," Malayan Economic Review, Vol. XI, No. 1 (April 1966).

381. United Nations, Asian Institute for Economic Development and Planning, "A Framework for Planned Economic Development of Lower Mekong Basin Countries," Bangkok: 1966.

382. Behrman, J. R., "Supply Response in Underdeveloped Agriculture: A Case Study of Four Major Annual Crops in Thailand, 1937-1963," unpublished Ph.D. thesis, M.I.T., Cambridge, Massachusetts: September 1966.

383. Janlekha, Kamol O., A Study of the Economy of a Rice Growing Village in Central Thailand, Bangkok: Ministry of Agriculture, 1957.

384. Neuchlerlein, D. E., Thailand and the Struggle for South East Asia, Ithaca: Cornell University Press, 1966.

385. Howard, Alan, "Land Activity Systems and Decision-making Models in Rotuna," Ethnology, Vol. 3 (1963), pp. 407-440.

386. Campbell, Alex, "Thailand: Is This Something to Fall Back On?" The New Republic, March 26, 1966, pp. 17-20.

387. Ayal, E. B., "The Impact of Export Taxes on the Domestic Economy of Underdeveloped Countries," unpublished manuscript, July 1964.

388. Woodson, T. T., and W. W. Gardiner, "Report on Survey of Thailand for Rural Industrial Technical Assistance Projects," Los Angeles: University of California, Department of Engineering, March 1965.

389. U.S. Department of Agriculture, Economic Research Service, "Agricultural Diversification and Economic Development in Thailand: A Case Study," Foreign Agricultural Economic Report No. 8, Washington: March 1963, p. 34.

390. Columbia University School of Law, Public International Development Financing Research Project, "Public International Development Financing in Thailand," New York: 1963.

391. Brannon, R. H., "End of Tour Report," Bangkok: U.S. Operations Mission, Agriculture Division, 1963.

392. Goertz, Clifford, Agricultural Involution, Berkeley: University of California Press, 1963.

393. Grist, D. H., Rice, 3rd ed., London: Green and Co., Ltd., 1959.

394. Matsuo, T., Rice Culture in Japan, Tokyo: Ministry of Agriculture and Forestry, 1954.

395. Thailand, Government of, Ministry of Agriculture, Rice Department, Annual Report on Rice Production in Thailand: 1959, 1960, 1961, Bangkok: 1962, 1963, 1964.

396. -----, -----, -----, "Annual Changwat Rice Area and Production Estimates 1937-1963," unpublished statistics (in Thai), Bangkok: 1939-1965.

397. -----, National Statistical Office, Household Expenditure Survey, B.E. 2505 - Advance Report, Bangkok-Thomburi Municipal Area, Bangkok: 1962.

398. -----, -----, Household Expenditure Survey B.E. 2506 - Advance Report, North and East, Bangkok: 1963.

399. -----, -----, Household Expenditure Survey B.E. 2506 - Advance Report, Central and South, Bangkok: 1963.

400. Tinbergen, J., Statistical Testing of Business Cycles, 2 vols., Geneva: League of Nations, 1939.

401. Klein, L. R., and A. S. Goldberger, An Econometric Model of the United States 1929-1952, Amsterdam: North Holland Publishing Co., 1955.

402. Dusenbery, J.S. et al., The Brookings Quarterly Econometric Model of the United States, Chicago: Rand McNally & Co., 1965.

403. Leontief, W., The Structure of the American Economy, Cambridge: Harvard University Press, 1941.

404. Leontief, W., ed., Studies in the Structure of the American Economy, London: Oxford University Press, 1953.

405. Chenery, H. B. and P. G. Clark, Interindustry Economics, New York: John Wiley and Sons, 1959.

406. Leontief, W. and M. Hoffenberg, "The Economic Effects of Disarmament," Scientific American, April 1961, pp. 3-11.

407. Dorfman, R., R. M. Solow, and P. A. Samuelson, Linear Programming and Economic Analysis, New York: McGraw Hill Book Co., Inc., 1958.

408. Sandee, J., "A Long-Term Planning Model for India," New York: United Nations, Department of Economic and Social Affairs, Commissioner for Technical Assistance, Report No. TAO/IND/22/Rev. 1, 9 June 1959.

409. Theil, Henri, et al., Studies in Mathematical and Managerial Economics: Vol. I, Optimal Decision Rules for Government and Industry, Chicago: Rand McNally & Co., 1964.

410. Eckaus, R. S. and L. Lefeber, "Capital Formation: A Theoretical and Empirical Analysis," Review of Economics and Statistics, May 1962, pp. 113-122.

411. Hahn, F. H., and R.C.O. Matthews, "The Theory of Economic Growth: A Survey," Economic Journal, Vol. LXXIV (December 1964), pp. 779-902.

412. Tinbergen, J. and H. C. Bos, Mathematical Models of Economic Growth, New York: McGraw-Hill Book Co., 1962.

413. Ranis, G. and J.C.H. Fei, "A Theory of Economic Development," American Economic Review, Vol. LI, No. 4 (September 1961).

414. von Neuman, J. and O. Morgenstern, Theory of Games and Economic Behavior, Princeton: Princeton University Press, 1944.

415. Luce, R. D. and H. Raiffa, Games and Decisions, New York: John Wiley and Sons, 1957.

416. Hadley, George, Nonlinear and Dynamic Programming, Reading, Massachusetts: Addison-Wesley Publishing Co., 1965.

417. Bellman, R. E. and S. E. Dreyfus, Applied Dynamic Programming, Princeton: Princeton University Press, 1962.

418. Tustin, A., The Mechanism of Economic Systems, London: William Heinemann Ltd., 1953.

419. Phillips, A. W., "Stabilization Policy and the Time-Forms of Lagged Responses," Economic Journal, Vol. 67 (June 1957), pp. 265-277.

420. Clarkson, G.P.E. and H. A. Simon, "Simulation of Individual and Group Behavior," American Economic Review, Vol. 50 (December 1960), pp. 920-932.

421. Orcutt, G. H., "Simulation of Economic Systems," ibid., pp. 893-907.

422. Shubik, Martin, "Simulation of the Industry and the Firm," ibid., pp. 908-919.

423. Forrester, J. W., Industrial Dynamics, Cambridge: The M.I.T. Press, 1961.

424. Orcutt, G. H. et al., Microanalysis of Socio-economic Systems, New York: Harper and Bros., 1961.

425. Balderstone, F. E. and A. C. Hoggat, Simulation of Market Processes, Berkeley: University of California Press, 1962.

426. Cohen, K. J., Computer Models of the Shoe, Leather, Hide Sequence, Englewood, New Jersey: Prentice-Hall, Inc., 1960.

427. Roberts, E. B., The Dynamics of Research and Development, New York: Harper and Row, 1964.

428. Nord, O. C., Growth of a New Product: Effects of Capacity Acquisition Policies, Cambridge: The M.I.T. Press, 1963.

429. Packer, D. W., Resource Acquisition in Corporate Growth, Cambridge: The M.I.T. Press, 1964.

430. Thorelli, H. B., R. L. Graves, and L. T. Howells, International Operations Simulation (INTOP) Player's Manual, New York: The Free Press, 1965.

431. Easton, David, A Systems Analysis of Political Life, New York: John Wiley and Sons, 1965.

432. Rothenberg, Jerome, "A Model of Economic and Political Decision Making," in Julius Margolis, ed., The Public Economy of Urban Communities, Baltimore: Johns Hopkins Press, 1965, pp. 1-38.

433. Boguslaw, Robert and Davis, R. H., "Simulating National Policy Formulation," SDC Magazine, Santa Monica, California: Systems Development Corporation, April 1965, pp. 5-16.

434. Coleman, J. S., "The Simulation of Processes in Social Controversy," unpublished manuscript, Baltimore: Johns Hopkins University, 1959 (?).

435. Pool, I. de S., R. P. Abelson, and S. Popkin, Candidates, Issues and Strategies: A Computer Simulation of the 1960 and 1964 Election, Cambridge: The M.I.T. Press, 1965.

436. Scott, M., W. A. Lucas and T. M. Lucas, Simulation and National Development, New York: John Wiley and Sons, 1966.

437. Tomkins, A. S. and Samuel Messink, eds., Computer Simulation of Personality: Frontier of Psychological Theory, New York: John Wiley and Sons, 1963.

438. Holland, E. P., B. Tencer and R. W. Gillespie, "A Model for Simulating Dynamic Problems of Economic Development," Cambridge: M.I.T. Center for International Studies report c/60-10, 1960.

439. Holland, E. P., "Simulation of an Economy with Development and Trade Problems," American Economic Review, Vol. LII, No. 3, (June 1962), pp. 408-430.

440. Holland, E. P. and R. W. Gillespie, Experiments in a Simulated Underdeveloped Economy, Cambridge: The M.I.T. Press, 1963.

441. Enos, J. L., "A Simplified Model of a Nation's Economy," Cambridge: M.I.T. Industrial Dynamics Project Report No. 239-1, May 26, 1961.

442. Centro de Estudios del Desarrollo de la Universidad Central de Venezuela and the Simulmatics Corporation (New York), "Simulation Model V-2, Abstract Formulation of the Simplified Global Model of the Economy of Venezuela," Caracas: August, 1964.

443. O'Connel, A., "Ensayo de un Modelo para Simular la Politica Economica en la Argentina," Instituto de Calculo de la Facultad de Ciencias Exactas de la Universidad de Buenos Aries, October 1964.

444. Shubik, Martin, "Simulation of Socio-Economic Systems: Part II: An Aggregative Socio-Economic Simulation of a Latin American Country," New Haven, Connecticut: Cowles Foundation Discussion Paper, 203, Part 2, August 8, 1966.

445. Pugh, A. L., Dynamo User's Manual, Cambridge: The M.I.T. Press, 1963, 2nd edition.

446. Markowitz, H. M., B. Hausner, and H. W. Karr, SIMSCRIPT: A Simulation Programming Language, Santa Monica, California: The Rand Corporation, RM-3310-PR, November 1962.

447. Heady, E. O. and J. L. Dillon, Agricultural Production Functions, Ames: University of Iowa Press, 1962.

448. Ruttan, V. W., The Economic Demand for Irrigated Acreage, Baltimore: The Johns Hopkins Press, for Resources for the Future, Inc., 1965.

449. Minami, Ryoshin, "Population Migration away from Agriculture in Japan," Economic Development and Cultural Change, Vol. 15, No. 2, Part 1 (January 1967), pp. 183-201.

450. Kerk, Dudley and Dorothy Nortman, "Population Policies in Developing Countries," Economic Development and Cultural Change, Vol. 15, No. 2, Part 1 (January 1967), pp. 129-142.

451. Hawley, A. H. and V. Prachuabmoh, "Family Growth and Family Planning in a Rural District in Thailand," in Family Planning and Population Programs: A Review of World Developments, Proceedings of the International Conference on Family Planning Programs, Geneva 1965, Chicago: University of Chicago Press, 1966, pp. 523-544.

452. Usher, Dan, "Income as a Measure of Productivity: Alternative Comparisons of Agricultural Productivity in Thailand," Economica, Vol. XXXIII, No. 132 (November 1966), pp. 430-441.

453. Ford Foundation, "New Technology for Indian Family Planning," India Program Letter No. 137, New Delhi: May 19, 1966.

454. Klein, L. R., Economic Fluctuations in the United States, 1921-1941, New York: John Wiley and Sons, 1950.

455. Walters, A. A., "Production and Cost Functions: An Econometric Survey," Econometrica, Vol. 31, Nos. 1-2 (January-April 1963), p. 25.

456. Lefeber, I., and Chakravarty, S., "Wages, Employment and Growth," Kyklos, Vol. 19, No. 4 (1966), pp. 402-620.

457. Simonet, P. A., "Harmonious Development in Thailand," Finance and Development, Vol. 3, No. 3 (September 1966).

458. Behrman, J. R., "Price Elasticity of the Marketed Surplus of a Subsistence Crop," Journal of Farm Economics, Vol. 48, No. 4 (November 1966), pp. 875-893.

459. "The Hearts and Minds Contest...," The Economist (London), April 1, 1967, pp. 25-26.

460. Stoleu, L. G., "An Optimal Policy for Economic Growth," Econometrica, Vol. 33, No. 2 (April 1965), pp. 321-348.

461. Uzawa, H., "On a Two-sector Model of Economic Growth: I," Review of Economic Studies, Vol. XXIX (October 1961) and "II," Vol. XXX (June 1963).

462. "Thailand Helps Itself," The Economist (London), May 6, 1967, pp. 560-564.

463. Nairn, R. C., International Aid to Thailand -- The New Colonialism?, New Haven: Yale University Press, 1966.

464. Naylor, T. H., J. L. Balintfy, D. S. Burdick, and K. Chu, Computer Simulation Techniques, New York: John Wiley and Sons, 1966.

465. Arrow, K. J., H. B. Chenery, B. Minhas, and R. M. Solow, "Capital-Labor Substitution and Economic Efficiency," Review of Economics and Statistics, Vol. XLIII (August 1961).

466. Barlow, R., "The Economic Effects of Malaria Eradication," American Economic Review, Vol. LVII, No. 2, May 1967, pp. 130-148.

467. -----, The Economic Effects of Malaria Eradication, Ann Arbor: School of Public Health, University of Michigan, 1967 (?).

468. Dano, Sven, Industrial Production Models -- A Theoretical Study, New York: Springer-Verlag, 1966.

469. Bodkin, R. G. and L. R. Klein, abstract of "Nonlinear Estimation of Aggregate Production Functions," Econometrica, Vol. 34, No. 5, supplementary issue, 1966, p. 113.

470. Mallihamas, W., "Industrial Promotion in Thailand," unpublished Ph.D. thesis, University of Wisconsin, 1967.

471. Sanittanant, Sura, "Thailand's Rice Export Tax: Its Effect on the Rice Economy," unpublished Ph.D. thesis, University of Wisconsin, 1967.

472. Prais, S. J. and H. S. Honthakker, The Analysis of Family Budgets, Cambridge: Cambridge University Press, 1955, section 7.2.

473. Nakamura, J. I., Agricultural Production and the Economic Development of Japan 1873-1922, Princeton: Princeton University Press, 1966.

474. Ohkura, K., The Growth Rate of the Japanese Economy Since 1878, Tokyo: Hitotsubashi University Press, 1957.

475. Taira, Koji, book review on 473, American Economic Review, Vol. LVII, No. 4, September 1967, pp. 941-943.

476. Houthakker, H. S. and J. Haldi, "Household Investment in Automobiles," in Consumption and Savings (Friend and Jones, eds.) Philadelphia: University of Pennsylvania Press, 1960, pp. 175-224.

477. Houthakker, H. S. and L. D. Taylor, Consumer Demand in the United States, 1929-1960, Cambridge: Harvard University Press, 1966, Chapter 3, Section V.

478. Clark, C., "Capital Requirements in Agriculture: An International Comparison," The Review of Income and Wealth, Vol. 13, No. 3 (September 1967).

479. Silcock, B., "The Overflowing Ricebowl," The Sunday Times (London), June 30, 1968, p. 8.

480. Scott, A. M., W. A. Lucas, and T. Lucas, Simulation and National Development, London: John Wiley and Sons, 1966.

481. Chorafas, D. N., Systems and Simulation, New York: Academic Press, 1965.

482. Naylor, T., J. Balintfy, D. Budick, and Cong Chu, Computer Simulation Techniques, New York: John Wiley and Sons, 1966.

483. Strauss, A., An Introduction to Optimal Control Theory, Lecture Notes in Operations Research and Mathematical Economics No. 3, Berlin: Springer-Verlag, 1968.

484. Naylor, T. H., W. E. Sasser, and W. H. Wallace, "Computer Simulation Experiments with Economic Systems: The Problem of Data Analysis" (resumé of paper presented at North American Regional Conference, December 1966), Econometrica, Vol. 35, No. 5, pp. 160-161.

485. Knight, J. B., "The Determination of Wages and Salaries in Uganda, " Bulletin of the Oxford Institute of Economics and Statistics, August 1967, pp. 233-264.

486. O'Connell, A. et al., "Modelo de Prevision a Corto Plazo," La Segunda Reunion Anual de Centros de Investigacion Economica, Mendoza, Argentina: December 1965.

(487.) Deleted from final draft.

488. Government of Thailand, National Statistical Office, Report of the 1967 Industrial Census, Volume 1, Bangkok: 1967.

489. Prasad, K., The Economics of a Backward Region in a Backward Economy - A Case Study of Bihar in Relation to the Other States of India, Calcutta: Scientific Book Agency, 1967.

490. Weil, R. L., Jr., "Optimal Growth under the Fixed Time, 'Maximal Distance' Objective," Economics of Planning, Vol. 6, No. 3 (1966).

491. Kurz, M., "Optimal Paths of Capital Accumulation under the Minimum Time Objective," Econometrica, Vol. 33, No. 1 (January 1965), pp. 42-66.

492. Lefeber, L., "Planning in a Surplus Labor Economy," American Economic Review, Vol. 58, No. 3 (June 1968), pp. 343-373.

(493.) Deleted from final draft.

494. Schulz, J. H., "The Future Economic Circumstances of the Aged: A Simulation Projection: 1980," Yale Economic Essays, Vol. 7, No. 1 (Spring 1967).

495. Tyner, F. H., and L. G. Tweeten, "Simulation as a Methodology for Appraisal of Farm Programmes," American Journal of Agricultural Economics, Vol. 50, No. 1 (Feb. 1968), pp. 66-81.

496. Naylor, T. H., D. S. Burdeck, and W. E. Sasser, "Computer Simulation of Experiments with Economic Systems: The Problem of Experimental Design," Journal of the American Statistical Association, Vol. 62, No. 320 (December 1967).

497. Baumol, W. J. and R. C. Bushnell, "Error Produced by Linearization in Mathematical Programming," Econometrica, Vol. 35, Nos. 3-4 (July-October 1967), pp. 447-471.

498. Behrman, J., Supply Response in Underdeveloped Agriculture, Amsterdam: North-Holland Publishing Co., 1968.

499. Roberts, P. O. and D. T. Dresge, "Simulation of Transport Policy Alternatives for Colombia," American Economic Review, Vol. LVIII, No. 2, May 1968, pp. 341-359.

500. Behrman, J. R., "The Adoption of New Products and of New Factors in Response to Market Incentives in Peasant Agriculture: An Econometric Investigation of Thai Corn and Kenaf Supply Responses in the Postwar Period," Discussion Paper No. 45, Philadelphia: University of Pennsylvania, Department of Economics, February 1967.

501. Bose, S., "Optimal Growth and Investment Allocation," Review of Economic Studies, October 1968, pp. 465-480.

502. Ando, A. and F. Modigliani, "Econometric Analysis of Stabilization Policies," American Economic Review, Vol. LIX, No. 2, May 1969, pp. 296-314.

503. Fromm, G. and P. Taubman, Policy Simulations with an Econometric Model, Washington: The Brookings Institution, 1968.

504. Furcaraccio, A.J.E., "Modelos: Problemas y Perspectivas," El Trimestre Economico, Vol. XXV, No. 137 (January-March 1968), pp. 75-86/

505. Parzen, E., Modern Probability Theory and Its Applications, New York: John Wiley and Sons, 1960, p. 181.

506. Cramér, H., Mathematical Methods of Statistics, Princeton: Princeton University Press, 1961, p. 237.

507. The Economist (London), August 30, 1969, p. 22.

508. Enke, S., "The Economic Aspects of Slowing Population Grwoth," Economic Journal, Vol. LXXVI, No. 301 (March 1966).

509. "75,000 Thais Face Starvation," The Times (London), April 21, 1969, p. 5.

601. Government of Thailand, Office of the National Economic Development Board, National Income of Thailand 1966 Edition, Bangkok: n.d.

602. -----, -----, National Income of Thailand 1965 Edition, Bangkok: n.d.

603. -----, -----, National Income of Thailand 1964 Edition, Bangkok: n.d.

604. -----, -----, Regional Gross Domestic Product, Bangkok: June 1965.

605. -----, National Statistical Office, Income and Expenditure of Farmers 1963, Bangkok: 1966 (?).

606. -----, -----, Statistical Yearbook Thailand 1966, Bangkok: 1968.

607. -----, -----, Report on the Survey of Population Change, 1964-1967, Bangkok: 1969.

608. -----, -----, Household Expenditure Survey B.E. 2506 (1963) (Whole Kingdom), Bangkok: 1966.

609. -----, -----, Final Report of the Labor Force Survey: Rural Areas: 1966-1967, Bangkok: 1968.

610. -----, -----, Census of Business, Trade or Services, 1966 (Abridged Report), Bangkok: 1968.

611. -----, -----, Report of the 1964 Industrial Census, 3 vols., Bangkok: 1967 and 1968.

612. -----, -----, Report of the Labor Force Survey (Round 1, January 1963), (Rounds 2-3, February and March 1963), (Round 4, July 1963), Bangkok: 1964-1966.

613. -----, -----, Preliminary Report of the Labor Force Survey, All Municipal Areas, August-October 1967 and February-April 1968, Bangkok: May 1968 and January 1969.

614. United Nations, Demographic Yearbook, New York: yearly.

615. Guetzkow, H., "Simulations in the Consolidation and Utilization of Knowledge About International Relations," in Pruitt, D. G. and Snyder, R. C., eds., Theory and Research on the Causes of War, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969, pp. 296-300.